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TRAINING EFFECTIVENESS EVALUATION OF  
NAVAL TRAINING DEVICES. PART I. A STUDY  
OF THE EFFECTIVENESS OF A CARRIER AIR  
TRAFFIC CONTROL CENTER TRAINING DEVICE

Dorothy L. Finley, et al

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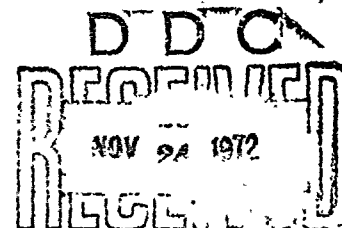
TRAINING EFFECTIVENESS EVALUATION OF  
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PART I: A STUDY OF THE EFFECTIVENESS OF  
A CARRIER AIR TRAFFIC CONTROL CENTER  
TRAINING DEVICE

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TRAINING EFFECTIVENESS EVALUATION OF  
NAVAL TRAINING DEVICES

ABSTRACT

This study evaluated the effectiveness of the Carrier Air Traffic Control Center (CATCC) training device in training teams to safely and efficiently control aircraft recoveries and to effectively maintain communications necessary to implement this control function. The results indicate the device is quite effective in that team, subteam, and individual performances generally improve during training; that student capability to deal with recovery contingencies and emergencies improves; that students generally perform acceptably in the operational job setting and that empirical evidence supports (but does not prove due to the study design) the transfer of training hypothesis; and that students gave the device moderate to high ratings on realism and effectiveness characteristics. It was concluded that device effectiveness could be further improved and that recommendations were worth consideration due to the considerable impact CATCC has on the efficiency and safety of carrier recovery operations. Recommendations were made relative to modifications and additions to the device hardware and software; utilization of the device for team training; personnel qualification requirements, including instructor, trainer "pilot", and student personnel; development of CATCC performance standards; and investigations which would determine recommended training schedules, analyze and evaluate other portions of the naval controller training program, and optimize the controller-display interface and the CATC system with respect to Naval Tactical Data System (NTDS) capabilities.

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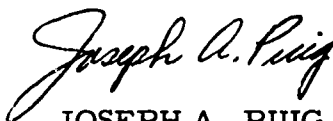
FOREWORD

This study is one in a long term program of in-house and contractual studies designed to evaluate the effectiveness of training devices. A primary purpose of these field evaluations is to determine if the trainers meet the user's needs, and to provide guidance for improvement in the use of simulators in particular training situations.

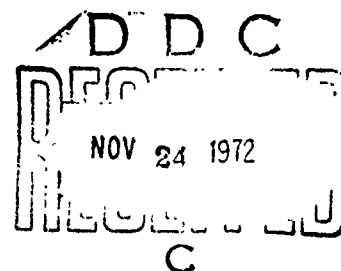
Carrier landing is the most dangerous routine activity of the naval aviator. An awareness of this fact, accompanied by the precise requirements of the task, make the recovery function one of a very high level of stress for the carrier air traffic control team. For this reason, effective training in this area is of prime importance to the Navy.

The present study has investigated student performance in both simulated and operational settings. The experimental data provide evidence of the effect that team and individual skill levels have on system effectiveness under both conditions.

This report has been arranged so that a synopsis of the study is presented in the first four sections. For readers who are interested in delving deeper, the details of the study are included in the appendices.



JOSEPH A. PUIG  
Project Psychologist  
Naval Training Device Center



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Finally, we would like to sincerely thank the gentlemen from the SS Midway and USS Constellation CATCCs who fully cooperated with our efforts to evaluate the training device and were so helpful.



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## SECTION I

## INTRODUCTION

## PURPOSE OF THE STUDY

Essential to effective development and management of training devices is evaluation of their effectiveness in actual user environments with respect to defined training objectives. The purpose of this study was to conduct such an evaluation on the Carrier Air Traffic Control Center (CATCC) team training device located at the Fleet Anti-Air Warfare Training Center at Point Loma, San Diego, California. In broad terms, the primary objectives for this device are to train CATCC teams to safely and efficiently control aircraft recoveries under operational IFR conditions and to effectively maintain the communications with pilot and ship-board personnel required to implement this control function.

The evaluation of CATCC trainer effectiveness was based on the following considerations: (1) The measured effect of training in the device on student performance levels, (2) Measurements and evaluations of later performance in the operational environment, and (3) Factors found to affect acceptance and/or systematic and effective utilization of this device. The first two considerations determined the present training effectiveness of the device, while the third consideration determined whether device effectiveness could be improved and how this could be accomplished.

## STUDY OBJECTIVES

The study design and measurement sets were determined from (1) The type of training program in use, (2) Training and operational schedules in effect during the investigation, and (3) Descriptions and function definitions for both the trainer and the CATCC operations it simulates. With completion of these efforts, it was possible to translate the study purpose into specific study objectives:

- a. Do students show evidence of improved performance in the training device as a team? As subteams? As individuals?

- b. Do students show evidence of learning to contend with recovery contingencies and emergencies in the training devices?
- c. Do students perform acceptably in the operational setting after completion of training and does the available evidence support the transfer of training hypothesis?\*
- d. How do student and instructor personnel evaluate the training device with respect to training effectiveness characteristics?
- e. How do student and instructor personnel evaluate the training device with respect to trainer realism characteristics?

#### GENERAL BACKGROUND DESCRIPTION\*\*

The carrier air traffic control system consists of several agencies, each with specific control functions and responsibilities for coordinating with the other agencies. As one of these agencies, CATCC has primary responsibility for aircraft requiring positive center control (e. g., under IFR conditions) within a fifty mile radius of the ship for which that ship is either the destination or point of departure. For aircraft operating under other control conditions, CATCC interacts with other agencies for control purposes and/or monitors to ensure traffic safety.

One of the more difficult CATCC activities, and the one which requires the most complete and fullest utilization of CATCC capabilities,

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\* Transfer of training could not be conclusively demonstrated under the permissible study design. Evidences which could be obtained were reviewed, however, to determine if the hypothesis was supported. See pp. 32-33 for a more detailed discussion.

\*\* Detailed descriptions of the study and its topic, CATCC, are provided in Appendix 1.

is the Mode III\* recovery of a scheduled flight of aircraft. The number of aircraft per scheduled recovery commonly ranges from 7 to 18. The equipment and personnel configurations for CATCC in full operation have been designed to implement this activity and it is this situation which the CATCC training device simulates.\*\*

CATCC recovery of a flight of aircraft is considered to be one of the more stressful air traffic control activities. The activity is stressful due to the task requirements for control within quite close position and time tolerances and for management of what can become a complex traffic pattern with many variables in operation. The level of stress is increased by the awareness of the extreme costs in terms of lives and aircraft that can be incurred by failing to meet task requirements.

The training program for CATCC students at FAAWTC consists of both classroom lectures (requiring one week for completion) and training device practice. Most of the classroom program is completed prior to device utilization. The device can be utilized anywhere from a week to several weeks depending on ship schedules and crew requirements. Student utilization of the device as a team results in a dynamic simulation of a complete scheduled Mode III recovery and provides training in both team coordination and the individual skills unique to each position. Such recoveries have a basic standard form (imposed by the objective and implementation methods) and can therefore be described as a problem which is practiced repetitively by student teams until proficiency is acquired. The problems are made more or less difficult by the insertion of problem variables, i.e., certain contingency and emergency situations, by instructor personnel.

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\* A glossary is provided on page 17.

\*\* A variation on this activity, the random Mode III recovery, makes very similar requirements on CATCC personnel and is occasionally simulated in the training device. However, due to its similarity and infrequent presentation during training, it will not be discussed further here.

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Students are ship-based and come as a group from that ship to the trainer. I. e. , these students are preparing to work together upon deployment rather than preparing as individuals who will later receive separate assignments. Further, whatever their previous experiences and training, the training received in this device represents the final preparation prior to deployment. The next use of their control capabilities is in the actual operational environment.

## SECTION II

### SUMMARY OF STUDY RESULTS

The results of the study will be summarized by answering the questions posed as study objectives. A detailed discussion of results and suggestions appears in Appendix B.

- a. Do students show evidence of improved performance in the CATCC training device as:

Teams? Yes, team performance clearly improves as a result of device utilization (see detailed results for the objective performance measures of aircraft separation error and recovery duration, pp. 43-52).

Subteams? Yes, subteam performance does improve as a result of device utilization (see objective performance measures of azimuth and glideslope errors and of communications efficiency and noise level, pp. 53-64).

Individuals? Yes, individual performance does generally improve or is corrected as a result of device training (pp. 64-72 ). The two exceptions appear to result from trainer utilization rather than trainer capability (pp. 67-69, 70-72 ).

- b. Do students show evidence of learning to contend with recovery contingencies and emergencies in the training device? Yes. Not only do they develop approaches to these problems but performance on objective measures indicates an increasing capability to meet system criteria during difficult, as well as easy, recoveries (pp. 44-64).
- c. Do students perform acceptably in the operational setting after completion of training and does the available evidence support the transfer of training hypothesis? The objective performance data indicate



the answers are yes. The students generally performed acceptably with better operational performances given by those who received more training (pp. 43-64, 66-67). The evaluative performance data (judgments made by the controllers, pilots, LSOs, and ORI team) all indicate acceptable operational performances after completion of training (pp. 73-75).

- d. How do student and instructor personnel evaluate the training device with respect to training effectiveness characteristics? Both personnel groups rated the trainer as moderately to highly effective across all the effectiveness characteristics (pp. 75-81). Critical comments and suggestions to improve trainer effectiveness are discussed (pp. 84-86).
- e. How do student and instructor personnel evaluate the training device with respect to trainer realism characteristics? Two sets of realism characteristics were evaluated, task environment realism and task performance realism. Both personnel groups rated the trainer as moderately to highly realistic on both sets of realism characteristics (pp. 75-81). Critical comments and suggestions to improve trainer realism are presented (pp. 81-84).

Comparison of ratings given to trainer realism vs. training effectiveness characteristics indicates the device generally received higher ratings on effectiveness than on realism. When students were asked to reevaluate the training device after having completed their first operational recoveries of the type for which they had received training, they rated the device as less real, but as more effective than they had while in training (pp. 75-81).

## SECTION III

## CONCLUSIONS

The CATCC training device has been evaluated from three standpoints: (1) Evaluation of the effect of repeated performance in the trainer on team, subteam and individual performance levels during the training period, (2) Evaluation of the acceptability of team, subteam and individual performance levels during initial recovery operations at sea, and (3) Evaluation of the training device in terms of specific effectiveness and realism characteristics. The conclusions regarding each of these are discussed in the following paragraphs.

## EFFECT OF REPEATED PERFORMANCE IN THE TRAINER

Because the majority of objective measures of performance used in this study are related to system effectiveness criteria for the CATC system, a demonstration of improvement in measured performance during training is especially relevant to carrier recovery operations involving CATCC. Data collected on these objective performance measures in the training device indicate the device is a very effective team and subteam trainer and can be effective as an individual trainer when necessary. The data further indicate that each team and subteam composition tends to be a somewhat unique entity which benefits from training as an entity. Although it must be assumed that some aspects of previous controller training and experience transfer to a new team or subteam composition, empirical evidence suggests a definite need for and benefit from training by newly formed teams and subteams.

## ACCEPTABILITY OF OPERATIONAL PERFORMANCE

Operational performance, as measured by the objective performance measures, was found to be acceptable. Further, evaluations of CATCC performance by the controllers themselves, pilots, LSOs, and the ORI team again indicate that operational performance was acceptable.

The differences in measured and observed performances between teams, subteams and individuals support the transfer of training hypothesis in that personnel with more training performed better. I.e., use of the CATCC trainer for training purposes appears to positively impact on operational Mode III scheduled recoveries. The evidence is not conclusive, however, because the study could not be structured so as to control or positively account for possible confounding variables.

## TRAINING DEVICE CHARACTERISTICS

The training device was evaluated as being moderately to highly training effective and realistic in terms of task environment and performance. Evaluations of controller performance by both controllers and pilots and evaluations of device characteristics indicate that, while the device is quite training effective with respect to contingency and emergency situations, it is not quite as effective with respect to guidance training. (Suggestions for improving trainer effectiveness were made with respect to several device training and realism characteristics, including guidance training (pp. 73-86).)

## SECTION IV

### RECOMMENDATIONS

Several recommendations can be made based on the results of this investigation which, directly or indirectly, relate to CATCC effectiveness. These recommendations fall into the categories of: (1) Capabilities and utilization of the CATCC training device, (2) Considerations regarding the rest of the controller training program, and (3) Considerations regarding the CATCC man-machine system.

#### CATCC TRAINING DEVICE RECOMMENDATIONS

Specific detailed discussions and suggestions relating to training device modifications and utilization appear throughout Appendices 1 and, especially, 2 and the reader is encouraged to review these sections. Only a few of these suggestions will be replicated here. Other recommendations presented here represent a synthesis of the detailed discussions with observations and interviews conducted throughout the investigation. The recommendations presented below fall into five areas: (1) Hardware and software considerations, (2) Utilization, (3) Personnel, (4) Performance standards, and (5) Training schedules.

**HARDWARE AND SOFTWARE CONSIDERATIONS** To the extent that training effectiveness is determined by trainer acceptance, training effectiveness will be improved (and capabilities expanded) by more realistic, complete, and reliable simulations of specific CATCC configurations, problems, and operating environments. For example, the addition of ICS and Bolter/Waveoff position simulation capabilities by addition of the appropriate hardware and hardware/software interfaces is particularly recommended because of the impact these equipments can have on team coordination procedures. It was found that the crew from one carrier did not completely accept the device as a training instrument due to its inability to simulate these aspects of their specific operating environment. Further, the evidence suggested that operational events which could have been very costly might have been avoided if the crew members had been able to train with their Bolter/Waveoff position simulated (discussed on pp. 83-85).

The capability of the device to simulate specific CATCCs could be further expanded by the addition of the other NTDS radar equipments in use and the capability to configure these equipments for training purposes. The extent to which this would be desirable should be determined from a careful analysis of feasibilities, alternatives, costs, and resultant improvements in training device flexibility and effectiveness.

The addition of a specific hardware item, the second channel of the SPN 42 PAR, is not only recommended - it is expected to become a reality in 1972. At present only one SPN 42 is in the training device and, as a result, Final Controller training for SPN 42-equipped carriers is not efficient and, probably, not entirely effective.

Based on comments made by students and instructors, device training is presently incomplete in that the Selective Identification Feature (SIF) of the IFF equipment cannot presently be simulated. This feature could reasonably be implemented with hardware and/or software modification. Since the CATCC device represents the final opportunity in training for students to integrate skills and capabilities into coordinated activity, and SIF represents a capability used in the operational environment, this recommendation should be given consideration.

The major difficulties and frustrations of the CATCC training device, from the standpoint of both instructors and students, can be summed up into two words: software problems. As discussed elsewhere (p. 31), thirty five percent of the observed recovery problems were terminated prior to completion due to problems in the software system. Several other recoveries were completed with difficulty. Training time was further reduced as a result of software system failures which rendered the trainer inoperable for periods of time. Simulation realism was degraded and controller irritation caused by inappropriate target behaviors resulting from programming inadequacies and system problems (see pp. 81 and 82 for examples). Further, attempts to realize a workable program to automate the NTDS synbology tracking function have thus far been frustrated (tracking is currently performed manually in the device and thus represents an additional task which realizes little benefit for the student controller).

The combined effects of the above problems is incomplete use of training time and an irritation which reduces student acceptance, frustrates instructional functions of the device, and results in less than the possible device training effectiveness and efficiency. It is recommended that consideration be given to the following: (1) Provision of increased support to the programming efforts underway both for CATCC and for the overall training system at FAAWTC; (2) The possibility of redesigning the software system with respect to CATCC. This device can operate independently from, rather than in coordination with, the other training devices constituting the overall training system. As a result, a redesign of the software and computer hardware systems might benefit both CATCC and other device operations; (3) An investigation to identify the downtime and degraded operation causes, and to determine alternative approaches to resolve identified software and computer hardware problems for both CATCC and the overall training system at FAAWTC; and (4) Selection and implementation of alternatives identified in the investigation.

**UTILIZATION** At present the CATCC training device is utilized for several purposes other than team training (see pp. 30-31). In training periods observed during this investigation, it was extensively used to cross-train individual controllers and to select the better team and subteam compositions. Use of the trainer as a team and subteam selection device indicates a high evaluation of the validity of trainer performances on the part of CATCC supervisory personnel and, based on the results of this investigation, that use of the trainer cannot be faulted. Use of the CATCC training device to cross-train individuals can be faulted, however, to the extent that it interferes with training of the selected teams and subteams. As observed previously, each team appears to represent a unique entity; an entity which requires and benefits from device training. When cross-training is done to the point that the teams selected for operational duty receive little training in their own unique team configurations, then the trainer is not being used effectively. Especially inasmuch as the team training environment is not one where a great deal of individualized instruction and attention can be given without interfering with team training requirements. I. e., neither team nor individual training is optimized in the

cross-training situation. The CATCC trainer admittedly is convenient for cross-training but it is recommended that it be used for such only to the extent that it is necessary to ensure position coverage and that sufficient training time will still be available for selected team training.

**PERSONNEL** In some discussions of trainer effectiveness, a distinction has been made between the trainer's training capability and its utilization. It must be pointed out that whatever a trainer's potential for training may be, it will not be fully realized unless it is utilized properly. It is sometimes the case that a rather inadequate training device is made highly effective by the manner in which it is utilized by instructor personnel to implement the training program. Whatever the capabilities of the CATCC training device may be, it has been made highly effective by the manner in which its instructor personnel have used it. The value of highly capable instructors in this training device environment is perhaps best explicated by student responses in the Trainer Evaluation form: "Instructors are highly skilled in problems for CCA" and "In training you have a chance to stop things and discuss the problems as they are happening, and discuss them with highly qualified instructors." It is recommended that the present level of instructor capability be retained to implement the CATCC training device programs. The effectiveness of this device appears to be very much a function of its utilization by instructor personnel; if this is indeed the case, then its continued effectiveness rests with the continuance of a highly qualified instructor staff.

At the present time there are no stated specific qualification requirements for CATCC instructor personnel; the level of instructor capability and motivation has been maintained as a result of timely action by the CATCC training staff. It is recommended that personnel qualifications be identified and documented for this billet such that the desired level of capability and motivation will be maintained.

Another personnel factor affecting trainer effectiveness is the PC&E "pilot", who plays an important role in the implementation of recovery problems. The discussion of this factor is presented elsewhere (p. 82) and will not be reiterated here. Due to the impact these personnel can have on recovery simulation adequacy, it is recommended that they be permanently assigned to the CATCC device

and have, to some extent at least, an aviation background. Given personnel meeting these requirements, the CATCC instructor staff could maintain the level of "pilot" performance required to provide a realistic simulation.

A final personnel factor that warrants consideration is that of the student. The effectiveness of the CATCC training device is constrained to the extent that (1) Members of a crew are at dissimilar levels with respect to training and capability, with some members not yet ready for team training, and (2) Incomplete teams are sent from the ship. The first item is a constraint because it tends to reduce the possible overall difficulty level of the recovery problems (thus limiting the amount of proficiency and knowledge that can be developed) and to present conflicting instructional requirements that can be difficult to resolve during recovery problem development. The second item is a serious constraint both in terms of the team training requirements discussed previously and because the realism of the simulation is degraded. It is recommended that the basis for CATCC assignments be reviewed and that CATCC crew members be more systematically scheduled for device training.

**PERFORMANCE STANDARDS** Inasmuch as the training device has been found learning effective and appears to affect operational CATC system performance levels, it appears reasonable to suggest that CATC system operations involving CATCC would benefit from the development and implementation of CATCC personnel qualification requirements using the CATCC trainer as the testing instrument. If the training device is capable of effectively serving operational needs, and it appears it is, then the necessary knowledges and implementation structure should be developed to optimize its impact on recovery operations. The establishment of (1) Standardized skill levels for those aspects of operational performance which can be predicted from trainer performance and (2) Requirements that these levels be met prior to deployment, would avoid inefficiencies and safety hazards resulting from CATCC performance (cf., pp. 48-52 and 66-67 ). It is therefore recommended that a research program be conducted to determine those qualification requirements valid for operational performance and that the procedures and regulations necessary to implement these requirements be developed.

**TRAINING SCHEDULES** It is not presently known what amount and scheduling of CATCC device training would best serve the needs of



the various types of crews using the device. In the present study, for instance, it was felt subjectively that the crew from one carrier had not received enough training, while the crew from the other carrier had perhaps been overtrained. It is suggested that an investigation be conducted to determine: (1) What levels of trainer performance provide the best transfer to the operational environment, (2) What factors other than performance levels determine optimum training schedules, and (3) Whether or not a set of recommended training schedules can be developed for the various types of crews.

#### CONTROLLER TRAINING PROGRAM RECOMMENDATIONS

The CATCC training device at FAAWTC is one of the devices providing team training. There are two other devices for team training (at Glynco and Norfolk) and there are various preparatory routes to these devices. It is suggested that these other programs may benefit from effectiveness evaluations similar to the one reported here. It is also suggested that an analysis of the overall naval controller training program in terms of operational requirements, interface requirements between discrete program units, and student input characteristics would result in a more efficient program which would more effectively serve the many different types and levels of operational requirements for controller personnel.

#### CATCC MAN-MACHINE SYSTEM RECOMMENDATIONS

The introduction of NTDS impacts on carrier operations in a number of different ways, including capability expansions, alternative procedural possibilities, and man-machine interface modifications. How to effectively integrate NTDS into carrier operations so that it will best serve operational objectives and requirements cannot be said to be completely resolved yet, at least in the case of CATCC. At least two investigations are recommended which relate to the integration of NTDS into CATCC operations.

It will be recalled that performance trends on one measure of team performance (Aircraft Separation Error, p. 48), crew rejection of NTDS symbology after a confliction during training (Number of Conflicts, p. 66), and controller evaluations of NTDS symbology effectiveness (p. 85), all raised the question of whether or not NTDS symbology should be provided in CATCC and/or how it should be

provided. It is therefore recommended that an investigation be conducted to determine if and how the controller-display interface should be modified with respect to the NTDS.

Secondly, it is recommended that detailed consideration be given on how to integrate NTDS capabilities and CATCC capabilities to realize their full combined potential and to maintain or improve CATC system performance. The development of NTDS allows for consideration of alternative possibilities (e.g., computer controlled approaches and landings using the Automatic Carrier Landing System). Tradeoffs are required with respect to capability values and the requirements to maintain these capabilities. Thus far, considerable effort has been devoted to the machine portion of the man-machine systems affected by the introduction of NTDS. It is suggested that increased attention be given to the man (operator) portion of these systems, and, as an important man-machine system, CATCC warrants this additional consideration.

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## APPENDIX A

## STUDY DESCRIPTION

## SUBJECT POPULATION

Data were collected on CATCC crews from two carriers, described herein as Ships One and Two. A total of 23 CATCC personnel were observed in the trainer; subsequently, 15 of these were observed in the operational environment while performing their first scheduled Mode III recoveries. (A more detailed data description appears in Table 1.) These recoveries took place two months after the final training period and were preceded by on-board CATCC activities that can best be described as part-task on-the-job training for scheduled Mode III recoveries.

The personnel from Ship One were observed during their first and third (the final) weeks of device training. Ship Two personnel were observed during their fifth and final week. It should be noted, however, that due to changes made in crew compositions and position assignments during training that the total training received by any one individual, subteam, or team may be substantially less than 3 to 5 weeks. For example, data collected during Ship One's third week of training described only first or second week performances. Data for Ship Two will be discussed as representing the fifth week of training but, in fact, it represents something less than this. It should also be noted that the week-long device training periods were generally separated by a one to two month time interval.

In view of the impact that team, subteam, and individual identity was found to exert on performance level, a detailed description of team identities in the training device as opposed to those on board the carriers is warranted. These differences will be recalled later in discussions of Results as they relate to questions of transfer of training and correlation of trainer and ship performance levels. Two team compositions were observed on board Ship One, neither of which was exactly like any of the team compositions measured in the trainer. The first team observed contained two personnel who had not received training in the trainer (identified as Team Nine in Results Section). Unfortunately, due to the constraints imposed by coordination requirements and too few data collection personnel,

TABLE 1. STUDY DATA DESCRIPTION

DATA DESCRIPTOR	OBSERVED IN TRAINING DEVICE		OBSERVED AT SEA	
	SHIP ONE	SHIP TWO	SHIP ONE	SHIP TWO
Performance Periods	1st & 3rd Weeks*	5th Week*	2 days	2 days
Number of Student Personnel (excluding CCAO & boardkeepers)	14	9	9	6
Number of Students Who Performed as:				
Marshal	8	2	1	1
Approach	8	5	3	2
Final	11	6	4	2
Supervisor	5	4	2	1
Number of Recoveries	32 **	14 **	4	4
Number of Teams Performing More Than One Recovery	9	2	2	1
Number of Subteams Performing More Than One Recovery	17	8	5	2

\* The third (Ship One) and fifth (Ship Two) weeks were the final training periods followed in both cases by operational recoveries of the same type two months later. Operational data were collected at these times.

\*\* Not all of the observed recoveries were completed due to software problems. Depending on extent of recovery completion, data was obtained on some subset of performance measures.

data could not be collected on several measures for this first team. In the second team observed on Ship One (Team Ten), the two "untrained" personnel had been replaced by persons who had performed many recoveries in the trainer in their assigned positions. In addition, one of the "trained" personnel on the first team had been replaced by a controller with considerable previous experience in that position but who had not practiced in that position as a team member at any time during the training period. Most of the data presented will describe performance by this second team. Where extrapolations from trainer data to onboard data for Ship One appeared reasonable due to judged or exact similarities of team, subteam, or individual identify in trainer and ship environments, this will be discussed. Where "trained" vs. "nontrained" performance comparisons appear possible, these will also be pointed out.

The team composition for Ship Two data in the trainer vs. on board the ship was not identical, but was considered to be quite similar. One of the Approach control positions on board the carrier was filled by a controller who had received a week of training in the trainer with the other team members during their first week of device training. Again, trainer vs. ship extrapolations and comparisons based on performance data will be based on overall team and subteam similarities, and the consideration that one individual member was evaluated as talented, but had also received less training.

#### CATCC and CATCC OPERATIONS

The primary control positions for Mode III recovery operations on these ships are: Marshal and Subteams A and B, where each subteam consists of an Approach, or Letdown, Controller and a Final Controller. Other personnel directly involved in support or supervisory roles include the Carrier Controlled Approach Officer (CCAO), the Supervisor, and Boardkeepers for the marshal and final status boards. These positions are described in greater detail below. Each of the performance measures used in this study (listed in Tables 3 and 4) measured one of the following: (1) The entire team, with emphasis on the primary positions; (2) Each of the subteams; and (3) Individual controller positions. The basic personnel configuration for both the trainer and Ships One and Two is described in Figure 1.

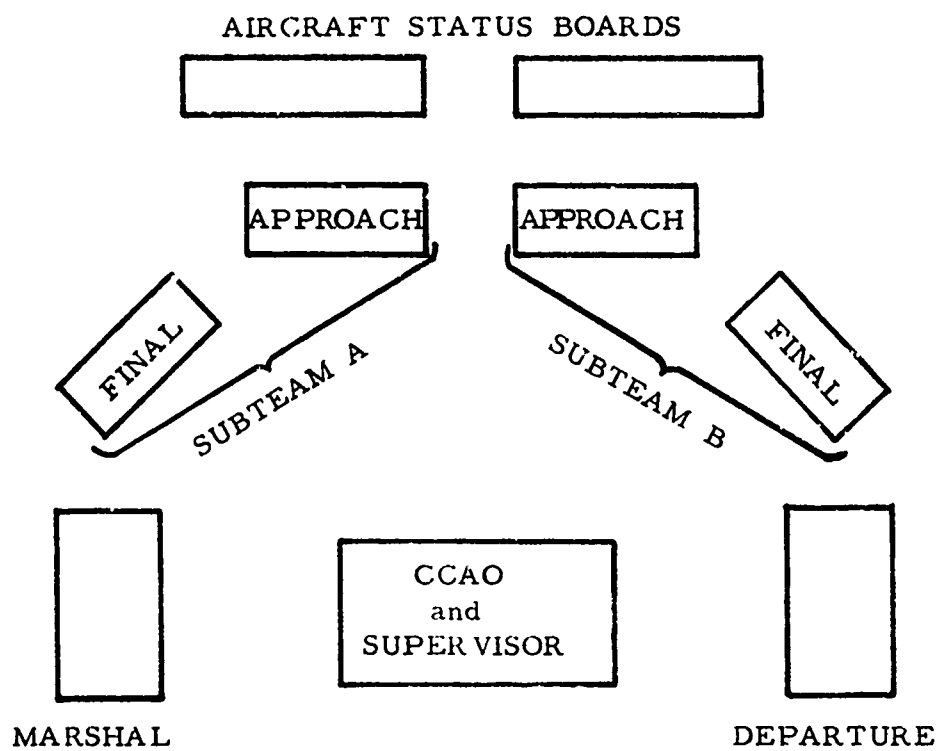


Figure 1. CATCC Layout

During recovery operations, the aircraft are initially under Marshal control. The Marshaller organizes aircraft within the marshalling configuration and ensures their individual entry into the approach pattern at the appropriate time. Aircraft handoffs from Marshal to Approach alternate between Subteams A and B. The handoff points on a recovery profile between Marshal and Approach Controller A or B, and then between Approach and Final Controllers are indicated in Figure 2. (Although there are several possible recovery profiles, Figure 2 describes the one generally used in the trainer and observed during operational recoveries.) Approach and Final Controllers are responsible for keeping aircraft aligned with the approach profile and path. Approach Controllers are additionally responsible for maintaining adequate separation between aircraft. If the aircraft enters a go-around (G/A), waveoff (W/O), or bolter status, the pilot then enters the bolter-waveoff pattern which parallels the approach path in the opposing direction. The Approach Controller then assumes his other function, which is to integrate that aircraft back into the approach path.

The flow for CATCC control and integration functions during scheduled Mode III recoveries is presented in Figure 3. The information flow which supports and implements these functions is described in Figure 4.

In addition to the brief description of position responsibilities provided by the above paragraphs, the following details are pertinent:

**CCAO AND SUPERVISOR** - these persons are responsible for the CATCC team and their actions. The CCAO provides the major interface between CATCC and other ship agencies which provide essential information and require coordination. The Supervisor coordinates the activities within CATCC as needed and is at the immediate command of any controller in the center for information or direction.

**MARSHALLER** - as the initial contact and controller for aircraft destined for the ship, he provides essential information (e.g., weather, altimeter setting, bearing, assigned airspace), collects essential information (e.g., position, fuel state, problems affecting recovery), and is responsible for the timing and sequence of departures from the marshall area.



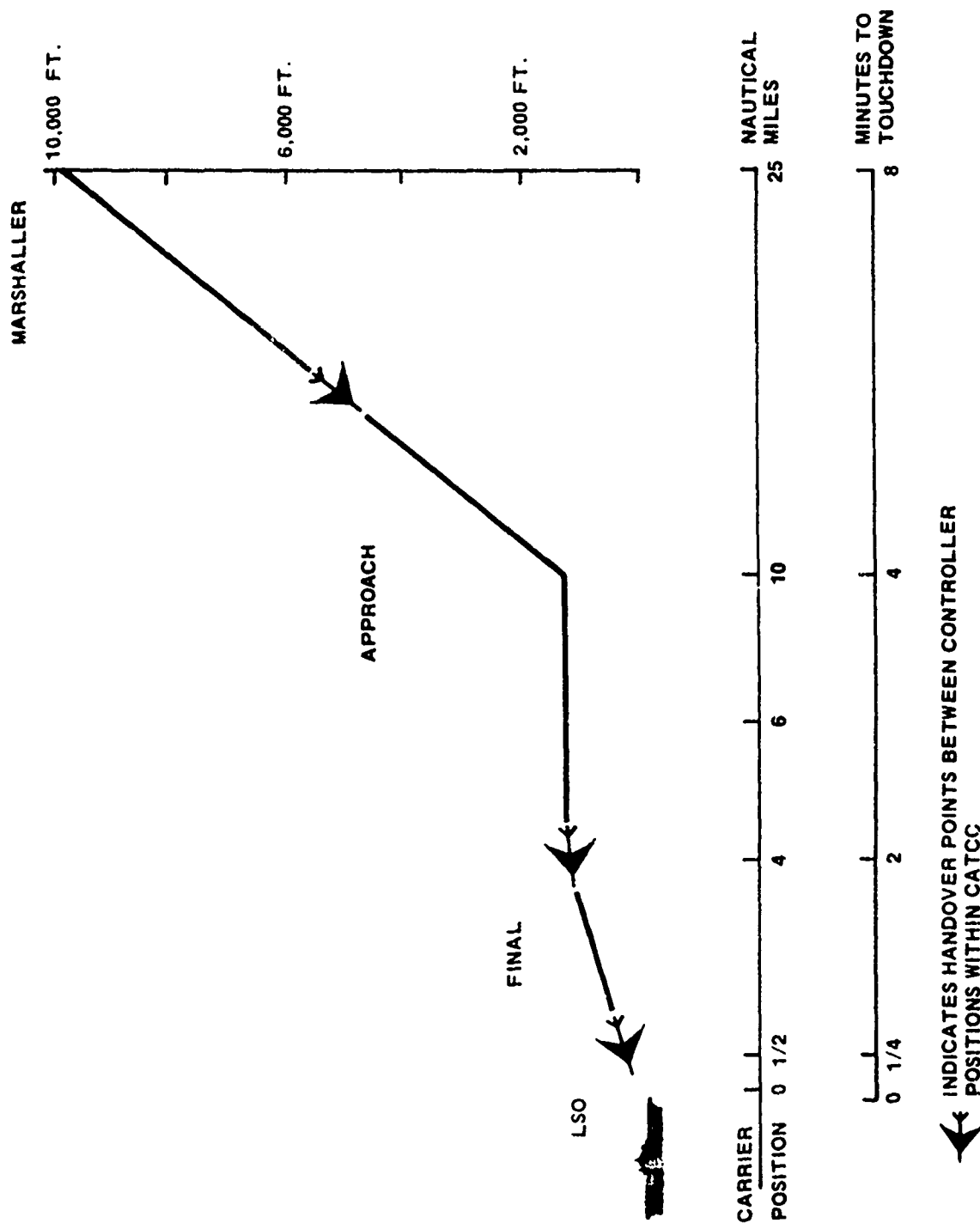


Figure 2. Approach Profile

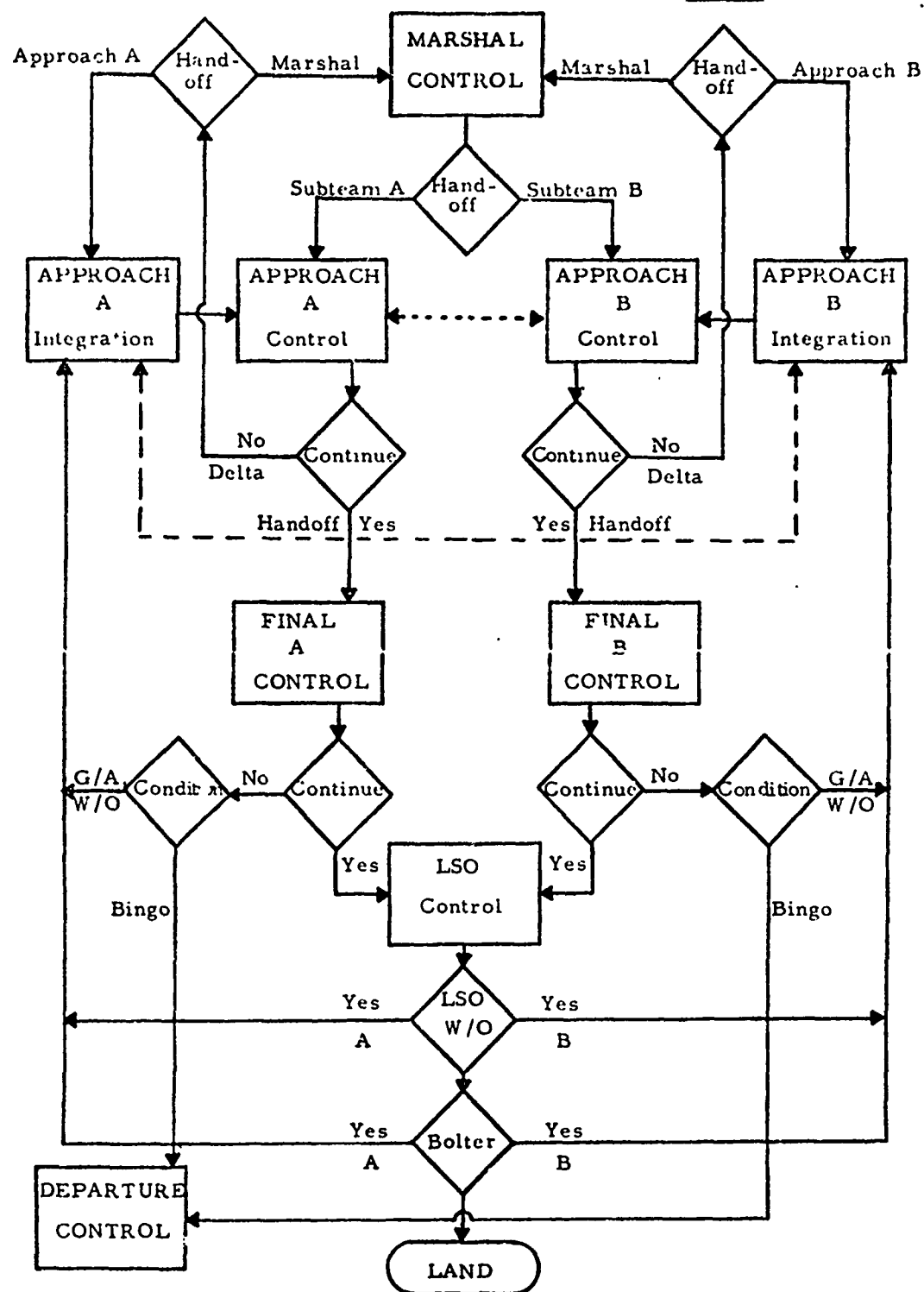


Figure 3. Carrier Mode III Scheduled Recoveries: Air Traffic Control Function Flow

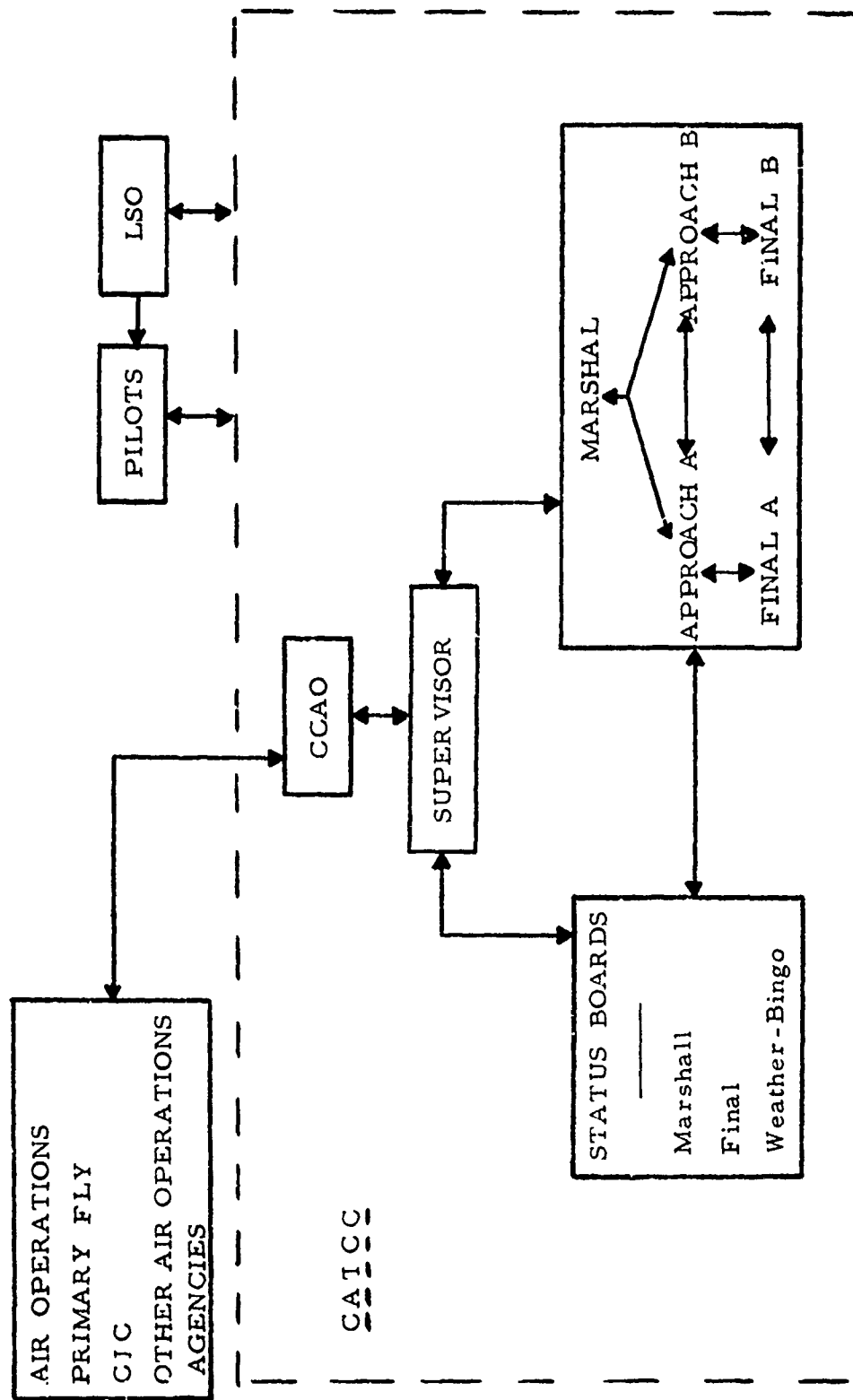


Figure 4. Carrier Mode III Scheduled Recoveries:  
Information Flow

APPROACH CONTROLLER (A OR B) - the approach controllers, like the marshaller, use area surveillance radar (ASR) scopes to perform their control and integration functions. And it is these scopes to which Naval Tactical Data System (NTDS) symbology is being introduced; these are radar symbols which track assigned aircraft and can be used by the controller to obtain supplementary information such as altitude.

FINAL CONTROLLER (A OR B) - the final controllers monitor precision approach radar (PAR) screens, closely controlling aircraft with respect to glideslope and azimuth position until either PAR minimums are reached or the LSO takes over.

STATUS BOARD KEEPERS (Marshal and Final) - these men are responsible for properly displaying and updating flight and aircraft information on their respective boards.

#### THE CATCC TRAINING DEVICE

DEVICE DESCRIPTION The CATCC Trainer consists of two rooms. One room is a CATCC mockup utilizing actual operating equipments to implement control positions. In operation, the mockup provides a complete and realistic environment for team control of a scheduled recovery.

The other room, called the CATCC Program Control and Evaluation (PC&E) center, contains the software interface and display facilities necessary to simulate video displays of aircraft and radar (ship and NTDS) symbology on the screens located in the mockup, to monitor student performance, and to insert problem variables. The aircraft movement patterns represented by the displayed video are determined by control actions at pilot stations in PC&E made in response to student controller commands. These patterns are implemented by computer software. A small section located in the mockup behind the primary area of team activity provides mockup instructor personnel with communication lines to PC&E personnel which are separate from the control voice channels between the students and PC&E "pilots".

Although all CVA CATCCs serve the same control functions, coordinate with the same ship agencies, and implement these functions with radar, voice channels and status boards, no two CATCCs are exactly alike. They differ in equipments (e.g., SPN 10 vs. SPN 35 vs. SPN 42 PARs, ICS available vs. no ICS available, etc.), equipment arrangement (although the general configuration is as described in Figure 1), coordination procedures within CATCC and between CATCC and other agencies, ship procedures and doctrine, problems encountered, and manner of implementing recoveries (e.g., recovery profile utilized, handoff points on the profile between positions, specialized personnel assignments such as maintenance of special displays, etc.).

The CATCC trainer has been assembled to simulate a generalized CATCC with respect to positions, position configuration, and equipment. The trainer has some flexibility with respect to equipment utilization. It has considerable flexibility with respect to the coordination procedures and recovery implementation methods that can be used by individual crews, and with respect to the types of problems simulated. Equipment flexibility is provided by the presence in the trainer of both of two distinct types of PAR found on ships presently in operation (specifically, one Final Controller can use either a SPN 35 or a SPN 42 radar) and by the built-in capability of using fewer than the usual set of three controller voice channels (a Marshall frequency and two primary approach frequencies, one for each subteam). Thus, although the mockup does not exactly replicate any single CATCC, simulation realism is enhanced not only by the use of actual operating equipments to implement and to display the results of the dynamic interaction between controllers and pilots, but also by the capabilities of the trainer to somewhat individualize training as per the special needs and requirements of particular crews from particular ships.

**RECOVERY PROBLEM VARIABLES** Mention has been made above of the use of recovery problem variables, i.e., contingency and emergency situations, to vary recovery problems in the mockup. The insertion of these problem variables by instructor personnel can serve three functions: (1) Training individuals and teams how to deal with each of the different types of problems, (2) Training individual controllers to properly tradeoff the control requirements per aircraft within the existing situational constraints so as to optimize the criteria

of safety and time, and (3) Developing the higher levels of proficiency needed for more difficult recoveries. Due to the impact of these variables on the analyses of collected performance data, they will be discussed in some detail here.

Each of the problem variables utilized in the training device have two characteristics in common: (1) They represent situations or variables which do occur during actual recovery operations and (2) They alter, in one or more ways, the performance requirements for one or more team members. Depending on which problem variables are utilized during a recovery simulation, where in the recovery profile they occur, subteam A vs. involvement, and the number, combination and timing of these variables, various team members or combinations of team members will be affected, or stressed, to varying extents. Examples of served trainer recoveries are described in Table 2, providing illustrations of problem variable use and how various control positions may be primarily affected. Each of the problem variables are discussed in the paragraphs below.

NTDS SYMBOLOGY - This CATCC Trainer has two training responsibilities: (1) Training CATCC teams to effectively control the recovery of aircraft flights and (2) Introducing CATCC crews to NTDS symbology and training them how to use it. The first training responsibility was the primary concern of this investigation and the study was accordingly structured. However, due to the facts that (1) NTDS symbol positions were manually controlled in the training device (automatic tracking software programs are being developed) thus constituting a new and secondary controller task, and (2) NTDS symbology is a new development which may or may not benefit CATCC, performance data was identified by this problem variable and controllers were questioned concerning it.

SHIP HEADING CHANGES The approach path set up for a flight recovery is determined by the expected path of the ship during the scheduled recovery period. If the ship's heading is changed with little or no advance notice to CATCC, this has two effects: (1) Radar displays require immediate corrective action and (2) Aircraft require timely information update and/or corrective control communications. Depending on the point in time during the recovery operation this problem variable is inserted, it may have minimal or extensive impact on the controllers.

TABLE 2. EXAMPLES OF TRAINER  
RECOVERIES OBSERVED

NTDS Symbology Used	Heading Change Time With Respect to Ramp Time, Minutes	Contingencies, Emergencies	Positions Primarily Affected	Number of Bolters, W/Os	Total No. of Approaches Completed
Yes	12 before	A/C with TACAN down	Marshall, LD/A *	8	19
Yes	1 before	A/C with fire in cockpit and rough engine  TACAN down	Marshall, LD B, Final B  Marshall LD B	5	16
No	No changes	A/C with Radio down	LD A	7	18
No	No changes	A/C with Radio down  Ship officers present	LD A  All positions	15	26
No	16 before 24 after	Fouled deck	LD A, B Final A, B	5	17
No	8 before	None	-	5	17
Yes	No changes	None	-	1	4

\* LD A - Letdown, or Approach, A

CONTINGENCIES AND EMERGENCIES Contingencies and emergencies can be defined as unscheduled, and hence unexpected, events which do have some probability of occurrence associated with them. Further, they are events which require increased attention and, often, additional and special control actions on the part of team members. The majority of the incidences included within this category relate to aircraft difficulties. The few exceptions are situations that were not simulated frequently enough to constitute a major problem variable category by themselves (cf., ship heading changes) but which did impact on controller performance as described above (e.g., fouled deck). The distinction between aircraft contingency vs. emergency problems arises from the need to do whatever is feasible to recover an emergency aircraft immediately. Examples of emergencies include fire in the cockpit and rough running engine. Examples of contingencies include failed or faulty navigation and communication equipments. Contingencies and emergencies primarily affect those CATCC positions in control of the aircraft; depending, however, on the pattern of problem insertion where more than one event is simulated and whether or not the aircraft is recovered on the first approach, the events may secondarily impact on the rest of the team members.

NUMBER OF BOLTERS, WAVEOFFS. The number of bolters and waveoffs occurring during the recovery of a standard sized flight, when used in conjunction with other information such delta instructions given, provides an indication of air traffic density and pattern complexity and of the extent to which the integration function had to be implemented (see Figure 3). The trainer is programmed to trap aircraft which are within certain position limits at one mile from the ramp and to waveoff those aircraft not within limits. The programs further include a random bolter function such that at least two to five aircraft will enter the bolter-waveoff pattern even if all approaches are controlled within the acceptable one mile limits. Instructor personnel can and do override the programs, however, to reduce or increase the load on particular controllers or on the team as a whole. The use of this problem variable is most directly related to instructor perception of student and team levels of proficiency and of what task load will best serve training objectives at that point in time. For example, if a student Approach Controller has not previously performed in this position - and aircraft controlled by his subteam are not within limits at one mile - then instructor personnel may override



the program and trap these aircraft so as not to overload this student. On the other hand, if a subteam is implementing the control function sufficiently well so that few aircraft enter the bolter/waveoff pattern, instructor personnel may override the program by boltering aircraft that would have been trapped; thus placing increased performance requirements on this subteam and, depending on the situation, the other subteam and/or the team as a whole.

The final column in Table 2, Total Number of Approaches Completed, describes observed recoveries but was not a problem variable. Its meaning will be discussed below.

**DEVICE UTILIZATION** Although the CATCC trainer is described as a team trainer, it actually is used in several ways:

- a. As a team training device, where team members are in essentially the positions they are most likely to be assigned to during carrier recovery operations.
- b. As a cross-training device. For example, controllers whose previous training and experience have been as Final controllers will perform in an Approach or Marshal position during some trainer recoveries.
- c. As a selection tool. The CCAO and, especially, the Supervisor will try the crew members out in several team configurations to determine the optimal ones. This evaluation may be made not only for position assignments but also for subteam compositions (i. e., which Approach controller should be teamed with which Final controller?).
- d. For individual training. It is assumed that more practice in any one position will result in greater position proficiency, no matter how the rest of the team membership varies.

Its use is further expanded by the type of crew using the device. These include (1) Newly formed crews which are relatively new to

each other (although 2 or 3 members may have served an earlier cruise together), to carrier air traffic control, and, in many cases, to the position they expect to fill; and (2) Experienced crews on layover, where most members worked together on the previous cruise and expect to fill the same positions on the next cruise. The latter type of crew use the trainer more for refresher training and to develop procedures and proficiency in problem areas experienced during the previous cruise. Teams of this type were not observed during the study time period, but it can be noted that they apparently tend to define their own training program to a greater extent than do the newly formed crews.

Device utilization in its intended manner, i. e., simulation of scheduled Mode III recoveries from Marshal check-in to recovery of the final aircraft, is interrupted or degraded by computer and software problems with relative frequency. Thirty five percent of the trainer recoveries had to be terminated prior to completion while several others were completed in spite of software problems (the total percentage of recoveries affected by software problems is estimated to be nearly sixty percent). The CATCC trainer is one of several tied into a central computer system. This system is modularized to some extent with respect to each of the separate trainers. As a result, recovery problems may be terminated prior to completion whenever software or hardware problems develop within either the CATCC subsystem or the overall computer system. Thus, although some amount of training is provided on these problems (amount of training depending on amount of problem completed), it is something less than what could be provided if these failures did not occur.

## STUDY METHODS

**STUDY DESIGN** The possible situations and schedules for data collection, i. e., the possible study design, were determined by the type of training program, the criticality and nature of the tasks being trained for, training and operational schedules, and available student populations (see pp. 2-4 and 17, and Table 1 for pertinent discussions). The study's data collection periods are indicated in the following matrix:

	TRAINER RECOVERIES, Week of Training			SHIP RECOVERIES
	First	Third	Fifth	
SHIP ONE	X	X		X
SHIP TWO			X	X

This can be roughly translated into experimental design terms as a 2x2 factorial with independent measures of the first factor and related measures on the second factor. The first factor is amount of training received at two levels: one week of training vs. approximately five weeks of training (data representative of a second week of training is available on a very few measures and is a deviation from the 2x2. See p.17 for a more detailed discussion of amount of training actually received.) The second factor is performance environment with trainer and ship being the two environments. Repeated within cell measures of the same performance indices were obtained allowing both rate and extent of learning within the training environment to be evaluated.

As is often the case in training device evaluations, a control group (i. e., a group performing ship recoveries without having received previous training) could not be measured to provide a complete assessment of transfer of training (CATCC is entirely too critical to the success of operational recoveries to purposely incur the risk of poor performance). Steps were taken, however, to allow an evaluation of adequacy, or acceptability, of performance during the first operational recoveries which were like those practiced in the trainer. These steps included not only the collection of operational data on the same parameters measured in the device but also the collection of performance evaluation data from personnel able to knowledgeably evaluate CATCC adequacy. Underlying the decision to evaluate operational performance adequacy was the supposition that transfer of training does or can occur and it represented an attempt to determine the adequacy of that transfer.

As discussed above, transfer of training cannot be conclusively demonstrated in this study. It will, however, be considered a reasonable inference to the extent that the following results occur:

- (1) Differences in operational performance levels between

teams, subteams and individuals are as would be predicted based on differences in amount of training received. It is understood that these differences may be confounded by individual and other differences to the extent that control groups do not exist and sample Ns are small. (2) Unplanned situations arise which do provide something akin to a control group. These occurrences will be pointed out in the Results Section.

Additional factors, or conditions, which might affect performance levels and thus confound the results of the study were either controlled, randomized, or measured and incorporated into the data analyses. These are discussed on pp. 39 - 40.

**STUDY MEASURES** Measurement data collected during the investigation consisted of three types: (1) Objective and subjective controller performance data, (2) Evaluative data on both controller performance and the training device, and (3) Descriptive data related to recovery conditions and events. Rationale and definitions for each of these sets of measures follows.

**OBJECTIVE PERFORMANCE MEASURES** CATCC constitutes an essential part of the overall CATC system, a part which becomes especially important during Mode III recoveries when its personnel are charged with direct implementation of system objectives. Under these conditions, it is reasonable to hypothesize a rather direct relationship between CATCC personnel performance levels and satisfaction of system objectives which are described by effectiveness criteria. This is relevant to the CATCC trainer evaluation in that overall training objectives are consonant with certain CATC system effectiveness criteria (see pp. 1-3 for discussions of training objectives and the CATC system). If data can be collected on measures of student performance which are related to these criteria, then any value in device utilization demonstrated by improved performance levels will be increased due to the relevance of these performance levels, not only to training objectives, but also to successful carrier recovery operations. To do this, however, requires that measures be developed which describe the performance of both the controller and the system or which, while describing only one, can be related to the status of the other.

The development of such measures for controller performance has been a difficult problem. Even though it is understood that air

traffic movement will be optimized to the extent that the factors of pilot behavior, equipment, environment and controller performance are optimized, measures of controller performance which related to system effectiveness criteria have been slow to develop. The problem stems, at least in part, from the fact that implementation of the control function must be contingent to a large extent on the specific situation - and situational conditions can vary tremendously. In addition, the relationships between individual controllers, controller teams, and their equipments are generally complex, multiple, interdependent and variable; further, the observable procedural implementation of control functions tend to vary not only as a function of situational but also individual preference and capability. As a result, the tendency has been to use either quite global qualitative measures or very detailed quantitative measures. These provide data which tend to be imprecise and unreliable (in the case of qualitative measurement) and without clear or immediate relationships to system effectiveness criteria (in either case).

Recently, however, a milestone study in the area of controller performance developed a measurement set which successfully measured the performance of the individual controller on parameters which clearly described ATC system effectiveness levels. This effort was performed by Buckley, et al, at NAFEC (Ref. 2). Using a set of simulated air traffic control environments for one controller position, they determined that data collected on certain "system level" measures were reliably determined by identity of individual controller and system load (specifically, aircraft density). I. e., they found that data on measures such as number of aircraft conflicts, aircraft time in the system, and flight time deviation for completed flights varied as a function of the parameters of load condition and the identity of the controller. Further, the authors commented that "... there are wide differences in the skill with which controllers perform when handling identical traffic under identical system conditions in air traffic control simulation exercises." In short, the Buckley et al. effort provided an indication that certain system level measures were sensitive to variations in controller performance level and might vary as a function of controller skill level.

For the purposes of this study, therefore, it was hypothesized that CATCC personnel performance is a major factor determining CATC system performance effectiveness in both simulated and operational environments and that data collected on measures of personnel performance which defined or were related to system effectiveness criteria would vary as a function of learning. Criteria for successful carrier recovery operations which are consonant with training objectives include:

- a. Minimum Recovery Time - necessary for reasons of tactical control and effective use of the carrier as a base for air operations.
- b. Minimum Accident Rate - required to maintain air operations capabilities.
- c. Optimized Carrier Subsystem Interfaces - CATCC operations interface with, and must be coordinated with, other carrier operations.

As has been previously observed and described (pp. 3 and 29-30) the CATCC training device can be evaluated not only as a team trainer but also as a subteam and as an individual control position trainer. Further, it was determined that the relationships between CATCC personnel and CATC system objectives occur and are measurable at the team, subteam, and individual position levels. It was therefore appropriate to specify the above learning hypothesis to these three personnel levels.

The objective performance measures are listed in Tables 3 and 4 and detailed definitions are provided both in Results, Section III, and Appendix 3. The tables serve to relate each of these measures to appropriate system effectiveness criteria and to appropriate personnel level. It will be noted in review of the tables that some measures appear under the special heading of "task" rather than "system". These measures of controller task performance impact on system operations, but do not necessarily determine criterial levels; that is, poor or omitted performance will not necessarily cause system degradation and good controller performance will not insure effective system performance. It will also be noted that Table 3 lists two measures which were subjectively, rather than objectively, scored (Communications Efficiency, Communications Noise Level). These two measures have been retained within this group rather than being placed under Evaluative Performance Measures because they (1) were a part of the measurement set collected on every recovery (whereas "evaluative" measures were not) and (2) described more discrete aspects of controller performance (as opposed to the more global "evaluative" measures).

TABLE 3. CATCC TEAM AND SUBTEAM PERFORMANCE MEASURES

CRITERIA MEASURED	CONTROL POSITIONS MEASURED	
	TEAM	SUBTEAM
SYSTEM MINIMUM RECOVERY TIME	<ul style="list-style-type: none"> <li>• TIME TO COMPLETE RECOVERY OF 11 AIRCRAFT</li> <li>• AVERAGE AIRCRAFT SEPARATION ERROR</li> </ul>	<ul style="list-style-type: none"> <li>* • COMMUNICATIONS EFFICIENCY</li> <li>• AIRCRAFT POSITION AT ONE MILE: AVERAGE GLIDESLOPE ERROR</li> <li>• AIRCRAFT POSITION AT ONE MILE: AVERAGE AZIMUTH ERROR</li> </ul>
	MINIMUM ACCIDENT	AIRCRAFT POSITION AT ONE MILE: AVERAGE GLIDESLOPE ERROR COMMUNICATIONS EFFICIENCY
OPTIMIZED SUBSYSTEM INTERFACES		AIRCRAFT POSITION AT ONE MILE: AVERAGE AZIMUTH ERROR AIRCRAFT POSITION AT ONE MILE: AVERAGE GLIDESLOPE ERROR
TASK MINIMUM COMMUNICA- TION NOISE		* • COMMUNICATIONS NOISE LEVEL

• Indicates the first table entry for a measure.

\* Subjective scores

TABLE 4. INDIVIDUAL CONTROLLER PERFORMANCE MEASURES

CRITERIA MEASURED	MEASURES (POSITIONS MEASURED)
SYSTEM	
MINIMUM RECOVERY TIME	<ul style="list-style-type: none"> <li>• EAT DEVIATIONS BEYOND EAT ±.25 MINUTES NOT ACTED UPON (MARSHALLER)</li> <li>• MARSHAL INFORMATION BROADCAST: ACCURACY (MARSHALLER)</li> <li>• DEVIATION FROM SCHEDULED RAMP TIME FOR FIRST AIRCRAFT (LETDOWN A)</li> </ul>
MINIMUM ACCIDENT RATE	<ul style="list-style-type: none"> <li>• MARSHAL INFORMATION BROADCAST: ACCURACY (MARSHALLER)</li> <li>• NUMBER OF CONFLICTIONS (LETDOWN)</li> </ul>
OPTIMIZED SUBSYSTEM INTERFACES	<ul style="list-style-type: none"> <li>• MARSHAL INFORMATION BROADCAST: ACCURACY (MARSHALLER)</li> <li>• EAT DEVIATIONS BEYOND EAT ±.25 MINUTES NOT ACTED UPON (MARSHALLER)</li> <li>• USE OF PRIMARY APPROACH FREQUENCY WITHIN 1/2 MILE LIMIT (LETDOWN, FINAL)</li> </ul>
TASK	<ul style="list-style-type: none"> <li>• MARSHAL INFORMATION BROADCAST: COMPLETE-NESS (MARSHALLER)</li> <li>• RADAR CONTACT NOT ANNOUNCED TO PILOT (LETDOWN; FINAL)</li> </ul>

\* May be system affective, but only under unusual circumstances.



**EVALUATIVE PERFORMANCE MEASURES** In addition to objective performance measurement as described above, performance evaluative ratings and questionnaire and interview responses were obtained from student controllers, pilots, Landing Signal Officers (LSOs), and the Operational Readiness Inspection (ORI) team. These data served basically two purposes: (1) Provision of evaluations of the adequacy of controller performance during operational recoveries and (2) Explanations of events, possible causes, and possible remedies; both of these as perceived by intimately involved and cognizant personnel.

The evaluations by student controllers and by pilots were made by use of three and five point rating scales (ranging from Poor to Excellent) to describe controller performance level with respect to Communications, Guidance, Emergency Procedures, Contingency Handling, and Overall Performance. The pilots were required to do this for each position: Marshal, Letdown, and Final. In addition to performance ratings, evaluation packages for both the student controllers (Controller Evaluation Form) and the pilots (Pilot's Evaluation of Exercise) contained open-ended questions regarding possible problem areas, suggestions, and comments. These forms are presented in Appendix 4.

The evaluations by LSOs and the ORI team are derived from interview responses. A form was developed for the LSOs (see Appendix 4, LSO Evaluation of Exercise) which provided useful information, but, unfortunately, too few of the forms were completed to provide sufficient data for discussion in the Results Section.

**EVALUATIVE TRAINING DEVICE MEASURES** Both instructors and students completed CATCC Trainer Evaluation forms (see Appendix 4) which provided ratings of trainer realism and effectiveness characteristics, verbal responses explaining the basis for the ratings, and suggestions for improvement. All questions requiring a rating response presented a five point continuous scale, with end points designated as Low and High Effectiveness or Realism. Instructor evaluations were made for team training as a whole, while students evaluated the trainer in terms of their probable position at sea.

Evaluations of training device effectiveness were required for the following: overall effectiveness as a training device, development of crew coordination and skills, recovery problems and problem characteristics for training purposes, and compared to onboard training. In addition, space was provided to list effective and ineffective characteristics which

had not been identified by responses to other questions. Questions were also asked regarding the effectiveness and usage of NTDS symbology.

Evaluations of training device realism were required for: target and radar symbology presentation on the displays, target behavior on the displays, situational response to controller performance, recovery problems, communication, guidance control, contingency handling, emergency situations, and the controller's own performance. A final question was asked regarding any additional comments, suggestions or statements the respondent might wish to make.

DESCRIPTIVE DATA If the conditions under which operators perform and the nature of the problem they deal with are constant, then operator performance levels should be determined only by operator characteristics - such as amounts of training received. To the extent conditions and the problem are variable, however, these variations may tend to affect performance levels. A number of condition and problem variables may affect CATC system performance levels depending on whether or not they occur and the extent to which they occur; descriptive data were collected on these. It was expected that certain of these would require consideration during data analysis. It was hoped that the others would either not vary to any extent (i. e., be controlled variables) or would vary equivalently under the conditions to be compared (i. e., be randomized variables). As it turned out, variables behaved as expected and hoped. They can be separated into variable groups which serve to identify them:

- a. Problem variables (see pp. 26-30).
- b. Other significant events - for example, unexpected equipment failures, failures to respond or incorrect responses on the part of pilots to correctly given control instructions.
- c. Experience levels for the controller, pilot (both PC & E and carrier), and deck recovery crew personnel.
- d. Weather conditions.

Time-based records were kept for variables falling into groups a and b throughout each recovery and were later used in conjunction with data analysis. It was determined from data collected on group c and d variables that these variables had been either controlled or randomized. For example, PC & E pilot experience level was controlled throughout

the study. On the other hand, it was determined that carrier pilot experience level was randomized in that the pilot population for each carrier recovery constituted an independent and equivalent sample of carrier pilot experience.

**DATA COLLECTION METHODS** The data reported in this study were collected by two Bunker Ramo human factors personnel teamed with one to two FAAWTC instructor personnel, depending on availability. Which personnel collected data on which measures was dependent on the level of cognizance required and available sources of information at each data collection position. Certain measures required little experience (e.g., Marshal Information Broadcast: Accuracy and Completeness) while others required a substantial amount (e.g., ratings of Communications Efficiency). Instructor coverage on the latter measures was provided throughout the study to the extent possible, with the most complete coverage being provided during the early data collection periods.

The descriptive and quantitative information providing the measurement data was obtained by monitoring the control communication channels, extra-channel communications, radar screens, Marshal and Final status boards, and the mission clock or other correlated time piece.

**DATA ANALYSIS METHODS** Graphic analysis was selected as the most appropriate and efficient method for identification of variables contributing to data variations and subsequent development of learning curves. This decision was based on the facts that (1) the CATCC training program emphasized continued training of the same activities to develop proficiency, (2) each measure was an individual case in terms of analysis (due to problem variable usage and whether the measure related to team, subteam or individual performance), and (3) each measure was represented by small data samples (due to problem stoppages, cross training, and inability to always cover all data collection positions).

The primary contributors to performance variance were expected to be personnel differences, problem variables, and, of course, repeated use of the training device. These were indeed the major contributors (accounting for most of the variance) and analysis methods related to each are discussed in the following paragraphs.

The effect of personnel differences, i.e., the effect of team, subteam and individual identities on performance level, was controlled. That

is, a constant personnel membership was maintained for each data point within a performance curve.

It was determined during initial analysis activities that descriptive data on problem variables could be transformed into levels of problem difficulty (e. g. , "easy", "difficult") and that these levels of difficulty appeared to account for, or correlate with, performance variations not accounted for by personnel and learning stage differences. Once this had been determined, a level of difficulty was judged for each measure on each recovery problem. These judgments were made independently of other analyses to ensure nonbiased decisions.

Separate difficulty analyses per measure per recovery were necessitated by the facts that (1) Measures differed in terms of activities and positions measured and (2) The impact of problem variables varied as a function of activity measured and the time and conditions under which they occurred. I. e. , a recovery problem described as "difficult" for one measure may be described as "easy" for another measure. An illustrative example is provided by considering the varying impacts on performance that are possible for one problem variable, Ship Heading Change. An unexpected ship heading change occurring just prior to ramp time would not affect measures of the Marshal Information Broadcast, as this activity would already have been completed. The heading change would require the Marshaller to make an additional general information broadcast but this did not appear to impose any special load on the Marshaller. It would not be expected, therefore, that the aspect of Marshaller performance measured by EAT Deviations Beyond  $\pm .25$  Minutes Not Acted Upon would be degraded either. On the other hand, a heading change just prior to ramp time can impact on the Approach Controller measure, Deviation from Scheduled Ramp Time for First Aircraft. Further, any heading changes occurring throughout the interval between four minutes prior to ramp time and recovery completion may affect other measured performances for a period of from two to five minutes per heading change (e. g. , Average Aircraft Separation Error). This affect results from requirements that may arise for additional control decisions, issuance of more control instructions, and extra coordination efforts between team members. The extent of this effect on performance is judged by consideration of the occurrence and timing of other events in the problem. For example, a recovery may be judged as "difficult" for Subteam A because an unexpected heading change occurred when three of their aircraft were on the approach path within ten miles of the carrier, one of which was an emergency aircraft. The same recovery, however, may be judged as

"easy" for Subteam B because they had fewer aircraft under control, none of which presented pressing position or emergency control requirements.

The effect of problem variables was handled in one of two ways, depending on the comparative distributions of difficulty levels across data groupings developed for the construction of a learning curve. If the difficulty levels within a data group (a point on the learning curve) were quite similar, but varied across the data groups for that curve, and that variation correlated with performance level variations, then the difficulty level was graphically depicted. If, instead, difficulty levels varied randomly within data groups and the distributions were similar across the groups then any problem variable effects were considered to be randomized with similar average levels.

The majority of the remaining performance variance was accounted for by the variable of primary concern, amount of training device usage, or number of recoveries performed. This variable (and number of operational recoveries performed) provides the independent variable axis for graphs presented in the Results section.

Mention should be made of data reduction procedures used to ensure data which reflected controller performance rather than the operation of other factors. In some instances, in both trainer and operational environments, pilots either did not respond or responded incorrectly to controller instructions. The data for these instances was deleted from the data base under analysis. For example, if one of the five or six aircraft under the control of Subteam A did not respond to correctly given glideslope and azimuth corrections then the measured error at one mile for this aircraft was not considered in the derivation of mean position errors for that subteam.

## APPENDIX B

## DETAILED STUDY RESULTS

## INTRODUCTION

The empirical results of the investigation are presented and discussed in the following paragraphs and associated figures. Results derived from the objective performance measurement data are depicted graphically with the independent axis identifying the number of recoveries performed in the trainer per ship crew and in the operational environment. It will be recalled (see p. 17 ) that utilizable data for Ship One, with few exceptions, describes recoveries performed during the first week of training. The exceptions consist of three measures with data which could be described as second week performances. The data presented for Ship Two will reflect performances during something less than the fifth week of training. The results derived from the evaluative measurement data will be presented in tabular and bar graph form.

## OBJECTIVE PERFORMANCE MEASURES

The learning curves will be presented in three groups, representing team, subteam and individual performance. It will be observed that the graphs generally display improved performance as a function of repeated performance within each set of recoveries (i. e. , first week for Ship One, fifth week for Ship Two, operational recoveries for both ships). It will also be observed that performance levels generally improve across the two sets of trainer recoveries and that Ship Two performed better in most respects during operational recoveries despite difficult recovery problems. As the crews from only two ships were observed at different points in training these observations do not constitute conclusive evidence that five weeks of training results in better performance than one week; however, observation of the teams in the trainer and ship environments supports the conclusion that the measured performance differences were primarily the result of training differences. Relevant to the comparison of data for predictive purposes is the observation by instructor personnel that the crew from Ship Two had performed better during their fourth week of training than they did during the observed fifth week.

**TEAM\* MEASURE: AVERAGE AIRCRAFT SEPARATION ERROR** The data appearing in Figures 5 and 6 describe the average absolute deviation from an acceptable time interval between aircraft ( $1.0 \pm .5$  or  $2.0 \pm .5$  minutes) as measured at the carrier ramp.\*\* As can be seen by examination of Figure 5, two parameters were found to determine the mean performance levels for this measure: (1) Skill level, as described by number of recoveries performed as a team, and (2) Recovery difficulty level. As can be seen by examination of Figure 6, which presents an individual curve for each team, team identity was a third important determinant of aircraft separation error. Thus, the hypothesis of team learning in the device appears to be supported and the effect of two other variables on performance level has been described.

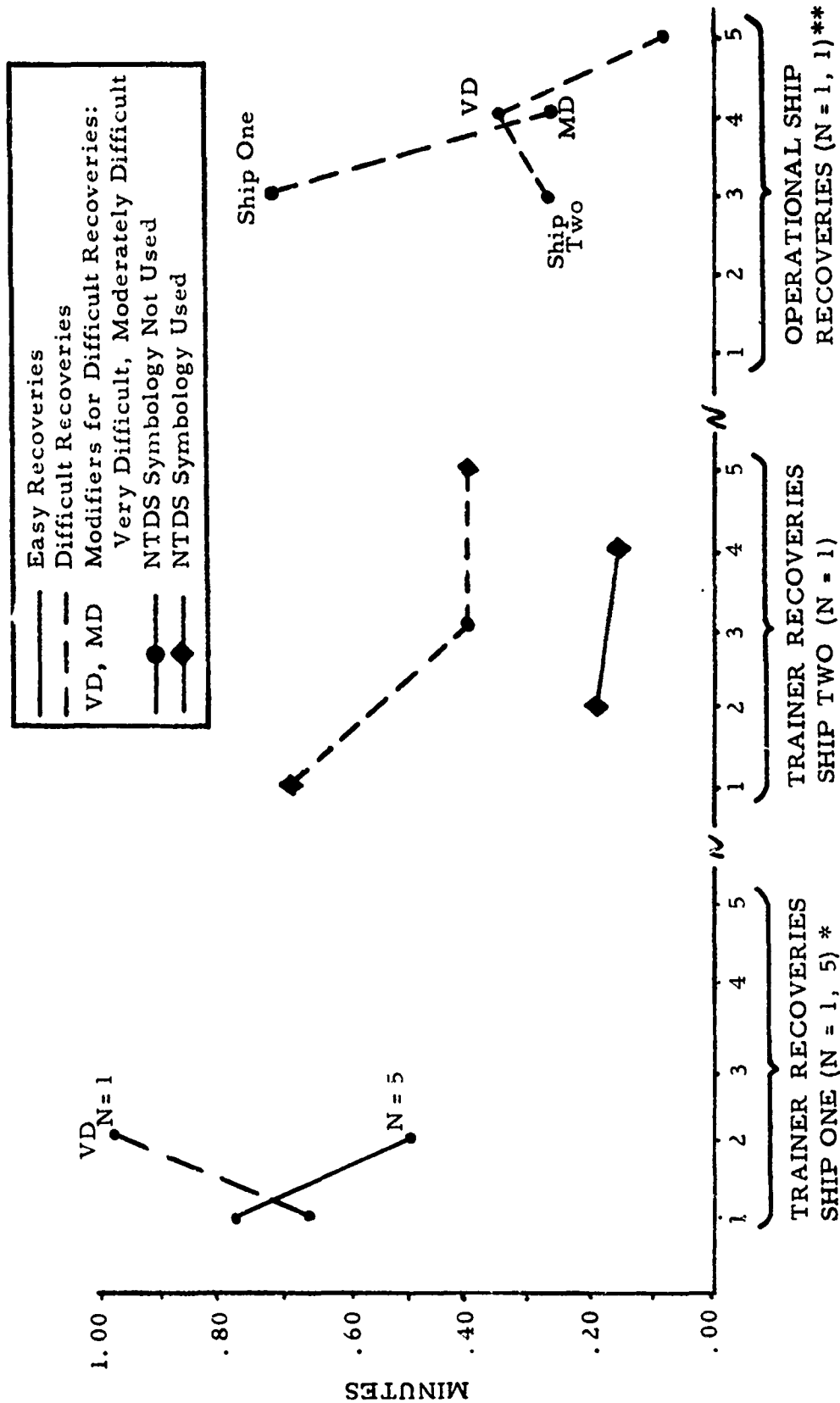
The question of whether or not transfer of training occurred can best be evaluated in terms of Figure 5, where selected individual Ship One team curves can be compared with Ship Two team curves (see pp. 17-19) regarding the comparative compositions of teams observed in the trainer vs. onboard). The Ship One teams selected for comparison are Teams Six (T6, Trainer Recoveries) and Ten (T10, Operational Ship Recoveries). Of the Ship One teams providing trainer data for this measure (e.g., T1, T7), Team Six was the most similar to Team Ten in terms of individual device training received, proficiency demonstrated and previous experience.

If positive transfer of training occurred and the operational performance level was a function of the amount of training received then the Ship One team should have performed more poorly than the Ship Two team in the operational environment (they received less device training and none as a team) - if the recovery problems were similarly difficult. The onboard recovery problems were not, however, similarly difficult. The operational recoveries performed by the Ship Two team were judged considerably more difficult than those performed on Ship One due to radar malfunctions that began during the third recovery, worsened during the fourth recovery, and continued during the fifth and last recovery observed. The radar problem was compounded by aircraft and other contingency

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\* A team is defined by constant composition with respect to membership and position. I.e., if the controllers in Final and Marshal exchange positions, a new team has been formed.

\*\* More detailed definitions are given for some measures in Appendix 3.



\* Curve for N = 5 describes average performance on sessions 1 and 2 across five teams. For performances on sessions 3-5, see Figure 4b.

\*\* Data could not be collected on several measures during recoveries 1 and 2.

Figure 5. Team Measure: Average Aircraft Separation Error - Mean Performance Curves



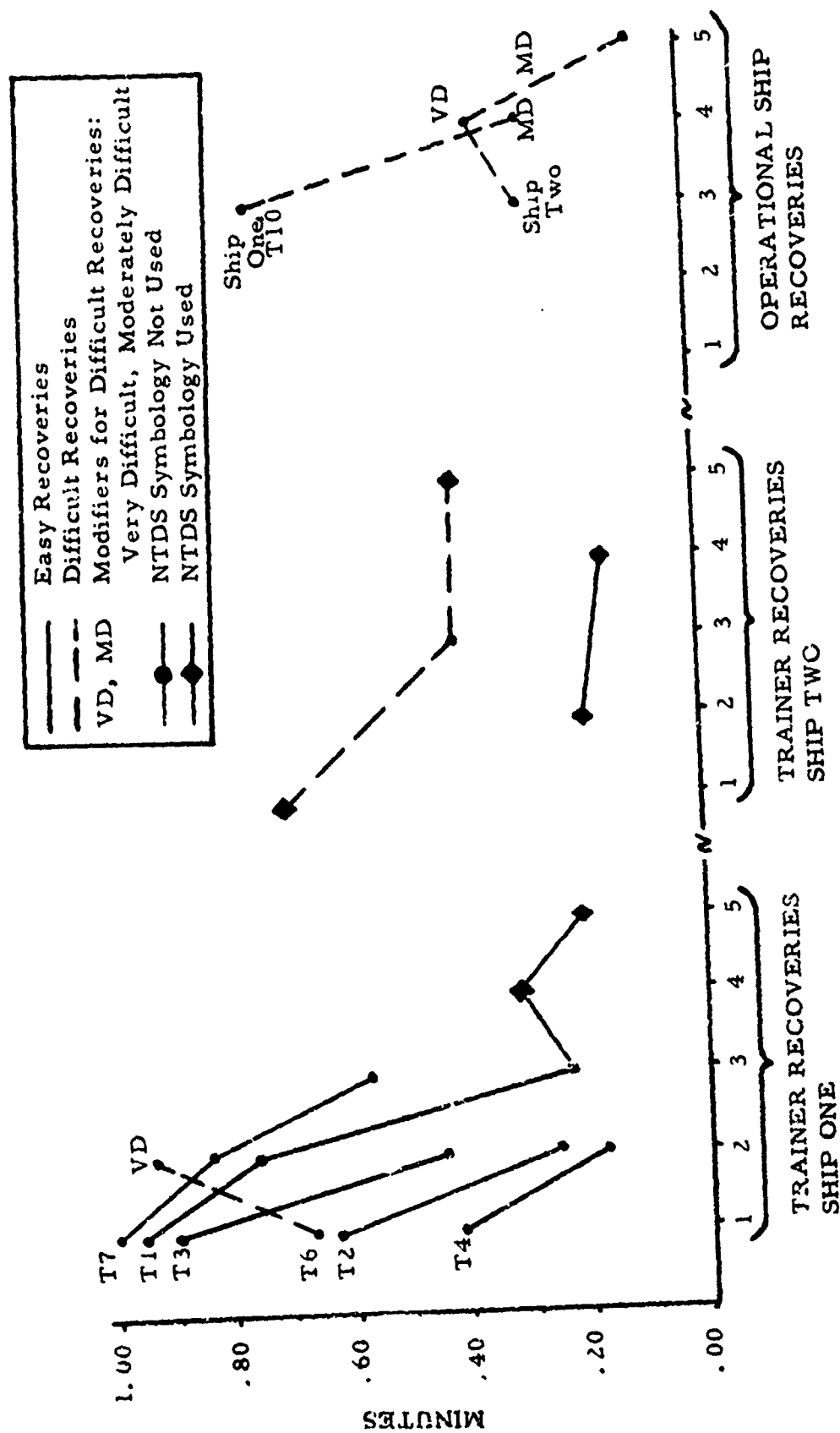


Figure 6. Team Measure: Average Aircraft Separation Error - Individual Team Curves

conditions. Thus, if positive transfer of training did not occur, and performance on this measure is as sensitive to recovery difficulty as it appears to be, then Ship One should have performed better than Ship Two.

With the above in mind, it can be observed in Figure 6 that the Ship One team (T6, T10) received less training and performed poorer than the Ship Two team in the shipboard environment. The amount of data and conditions of measurement are insufficient to support any firm conclusions regarding transfer of training on this measure (e.g., team differences may have confounded the results). It can only be said that the measured performance differences are definitely in the direction required by the transfer of training hypothesis.

Although a criterion is established for aircraft separation ( $1.0 \pm .5$  or  $2.0 \pm .5$  minutes), no operational data was located which described deviations from this criterion as measured in this study. As a result, evaluation of CATCC operational performance adequacy on Ships One and Two must be based on judgment, rather than on comparison with known data (see p. 32 for adequacy evaluation rationale). It would appear that the mean separation errors for the Ship Two team (.27, .35, and .08 minutes) were quite acceptable, especially in view of the fact that the errors resulted from an intentional increase in spacing between aircraft when radar presentations began to degrade. In contrast, separation does not appear to have been adequately controlled by the Ship One team. The error value on the third recovery was .72 minutes and the amount of separation between aircraft was quite inconsistent (e.g., 1.75, 4.00, 0.50 and 2.25 minutes describes spacing between five aircraft in sequence on this recovery). The .27 error value obtained on the fourth recovery by this team appears to represent an adequate performance, particularly since the spacing was more regular and the measured error describes a maintenance of increased spacing between aircraft. In summary, the team with more training performed quite acceptably; the team with less training did not do as well.

One final note of interest (the same phenomenon can also be observed on the next team measure) is the direction of the individual team curve for T6 for their two trainer recoveries (Figure 6). If previous individual training does transfer to the team situation (training programs generally presume this does happen to some extent at least) then the fact that T6 performed its first recovery, a difficult one, at a level similar to the easy first recoveries performed by T1, T2 and T3 is not surprising -- this recovery was performed on the final day of training for this ship's

crew. What is of interest is the sharp degradation of performance on T6's second recovery. This measure of team performance does appear to be sensitive to recovery difficulty, but note that the variation of performance level in response to difficulty by the Ship Two team during their fifth week of training is not nearly as extreme. A possible reason of T6's extreme performance degradation may be the difference in controller and team self-confidence and capability with respect to difficult problems when one vs. five weeks of training have been received. This point will be discussed again with reference to evaluative data (pp. 95-96).

It will be noted that certain of the data points in Figure 6 describe trainer recoveries in which NTDS symbology was utilized by the controllers. If the downward trend of the learning curve is hypothesized to continue until performance is perfected, then it would be expected that the separation error on recoveries 4 and 5 made by Ship One's T1 (these two recoveries were made even easier by use of a two minute interval between aircraft) and on recovery 5 made by Ship Two's team would have been smaller than they were. As noted earlier, this result does not necessarily evaluate the utility of NTDS symbology -- but it does suggest that imposition of a secondary task on the controller may affect performance of a primary function.

**TEAM MEASURE: TIME TO COMPLETE RECOVERY OF 11 AIRCRAFT**  
This team measure is defined as the time interval, in minutes, from Ramp Time to the trapping of the final scheduled aircraft. Certain descriptive data were used in the data reduction process for this measure; specifically, periods during which recovery operations were suspended (e.g., due to a fouled deck) and delays caused by the failure of other personnel groups to communicate essential information were subtracted from the total recovery time.

This particular measure is one which was not expected to be sensitive to changes in controller team skill level except, perhaps, in the grossest sense. Once the obvious data corrections described above were made, the time required to complete a scheduled recovery was expected to be primarily a function of other variables, many of which are reflected in the boiler/waveoff rate (e.g., pilot skill, weather conditions, LSO decision criteria).

The reason this measure was of interest, however, was because it appeared to tap an aspect of control team performance not covered by the other measures. Other measures in the objective measurement set

primarily describe the effectiveness of aircraft control with respect to integration into the approach path (separation error) or control on that path (separation error and glidepath errors) and the effectiveness of communications behaviors utilized to effect or make control decisions. An additional and very important aspect of controller team behavior is the decision-making management activities required to select the course of action for a developing or sudden problem, to develop traffic patterns suitable to a given situation, and to perform the trade-offs that must usually be considered. It was felt that the quantitative measure most likely to be consistently affected by this behavioral aspect would be recovery duration. For this reason, data for this measure was analyzed -- with surprising results.

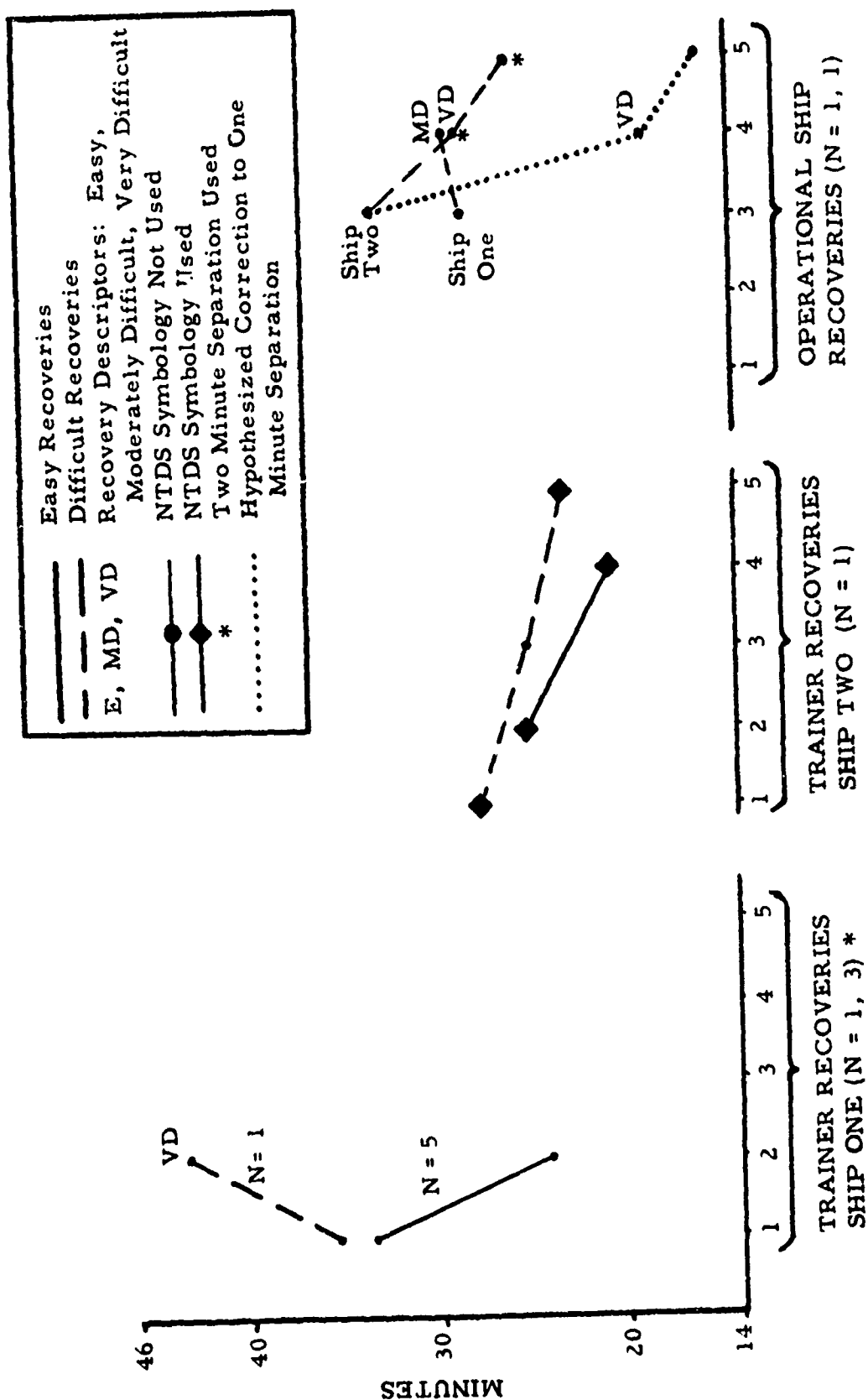
The results of the analyses indicate, first of all, that although bolter/waveoff rate may be strongly deterministic of recovery completion time when controller skill level and recovery difficulty are held constant -- it is not when these two parameters are allowed to vary. The data points depicted in Figures 7 and 8 represent recoveries which range in number of approaches\* from 12 to 26 quite randomly. Despite this, the majority of the variance for data on this team measure is accounted for by skill level, recovery difficulty level, team differences and a correction factor for two-minute separations.\*\* Whether or not these factors would account for the majority of variance under more usual conditions remains to be seen, but it is of interest that, when allowed to vary, they appear to exert such an influence.

The comments made on the previous measure regarding team compositions (T6, T10) and recovery difficulty levels as related to transfer-of-training considerations are applicable here when reviewing Figure 8. And the same evaluations regarding impact of team training on operational performance can be made, with some further support as described in the following paragraph.

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\* Number of Approaches = number of aircraft recovered + number of deck bolters/waveoffs + number of bingos/go-arounds/waveoffs initiated prior to deck.

\*\* As can be seen by reference to Figures 7 and 8, certain recoveries utilized a two- rather than a one-minute separation between aircraft. A hypothetical correction factor of ten minutes (a judgment only, based on several factors) was subtracted to create adjusted curves which are more comparable to the recoveries using one-minute separations.



\* NOTE: Curve for N = 3 describes average performance on sessions 1 and 2. For performances on sessions 3-5, see Figure 8

Figure 7. Team Measure - Time to Complete Recovery of 11 Aircraft - Mean Performance Curves

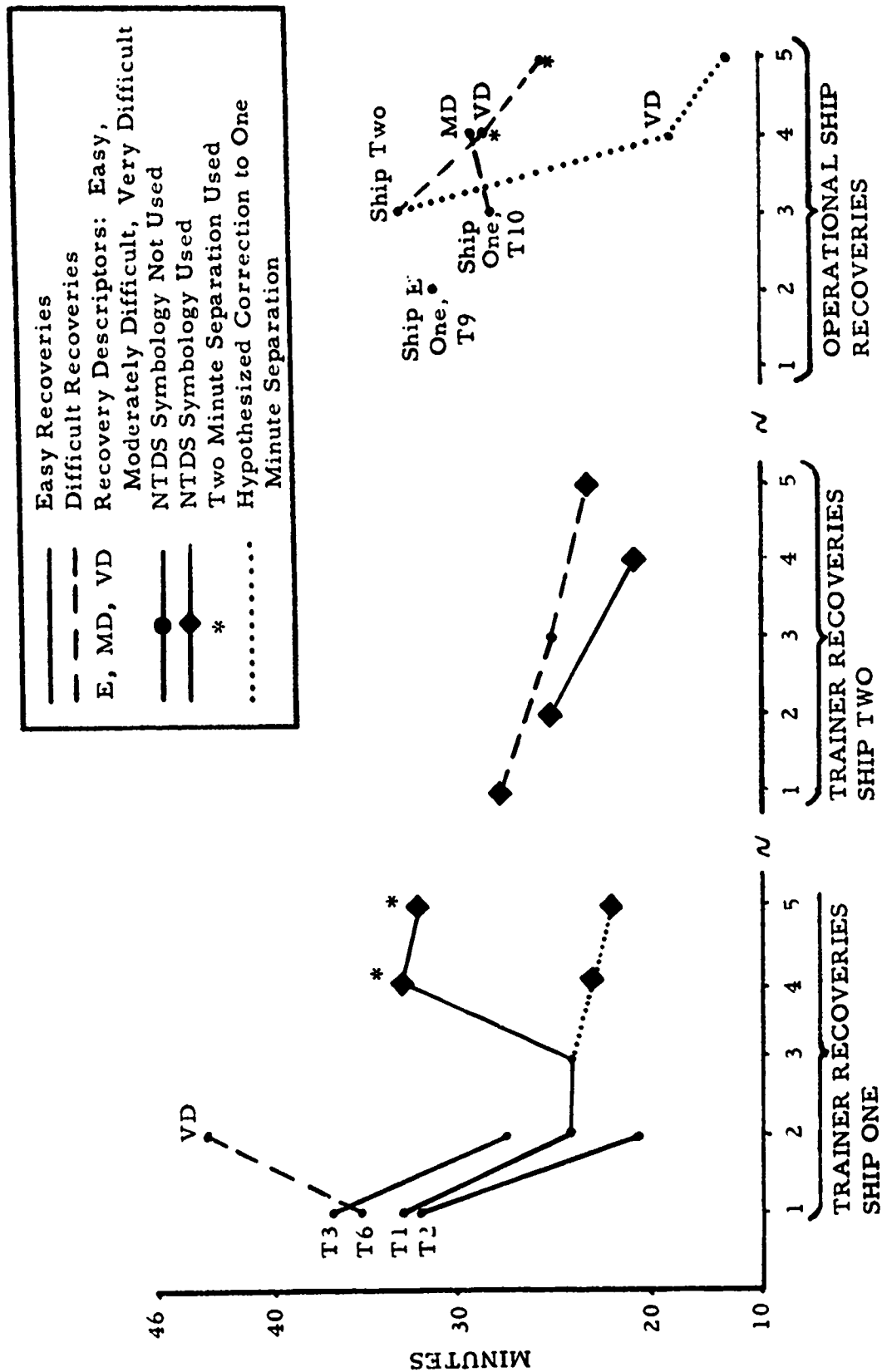


Figure 8. Team Measure - Time to Complete Recovery of 11 Aircraft - Individual Team Curves

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An additional data point was obtained on this measure which described performance by the first team observed on Ship One performing an easy recovery (T9, Figure 8). It will be recalled that this team had two controllers who had not received device training and, in addition, had not received device training as a team. Even though the recovery was the easiest one observed, measured performance was rather poor (see following paragraph re: acceptable recovery durations). If recovery difficulty affects this team measure as it appears to, then an even poorer performance would have occurred on a difficult recovery. Again, the difference between teams in operational performance levels is as required by the transfer of training hypothesis. From the limited evidence available, it appears that training of all team members as a team prior to on-the-job performance would benefit recovery operations efficiency.

A sample of data describing regular night recovery operations on another carrier was available to provide a basis for evaluating the adequacy of Ship One and Two teams on this measure (Ref. 1). Based on a regression equation developed from data on flights of 2 to 17 aircraft the expected recovery duration for 11 aircraft is 25 minutes with a possible range of 12 to 37 minutes (95% confidence interval). The actual data for 11 aircraft recoveries provided a mean time period of 24 minutes with a range of 19 to 34 minutes. These latter values can be compared to recovery time periods measured onboard Ships One and Two:

<u>SHIP ONE</u>	<u>SHIP TWO</u>		<u>ANOTHER CARRIER</u>
	Measured	Two-Minute Correction	
T9: 31	33	33	34
T10: 28	29	19	23
T10: 29	26	16	21
			19

Based on the above data, Ship One and Two team performances on this measure in their onboard environments appear acceptable. Again, however, T9's performance appears somewhat marginal for an easy recovery and it must be pointed out that this team did not receive the same training.

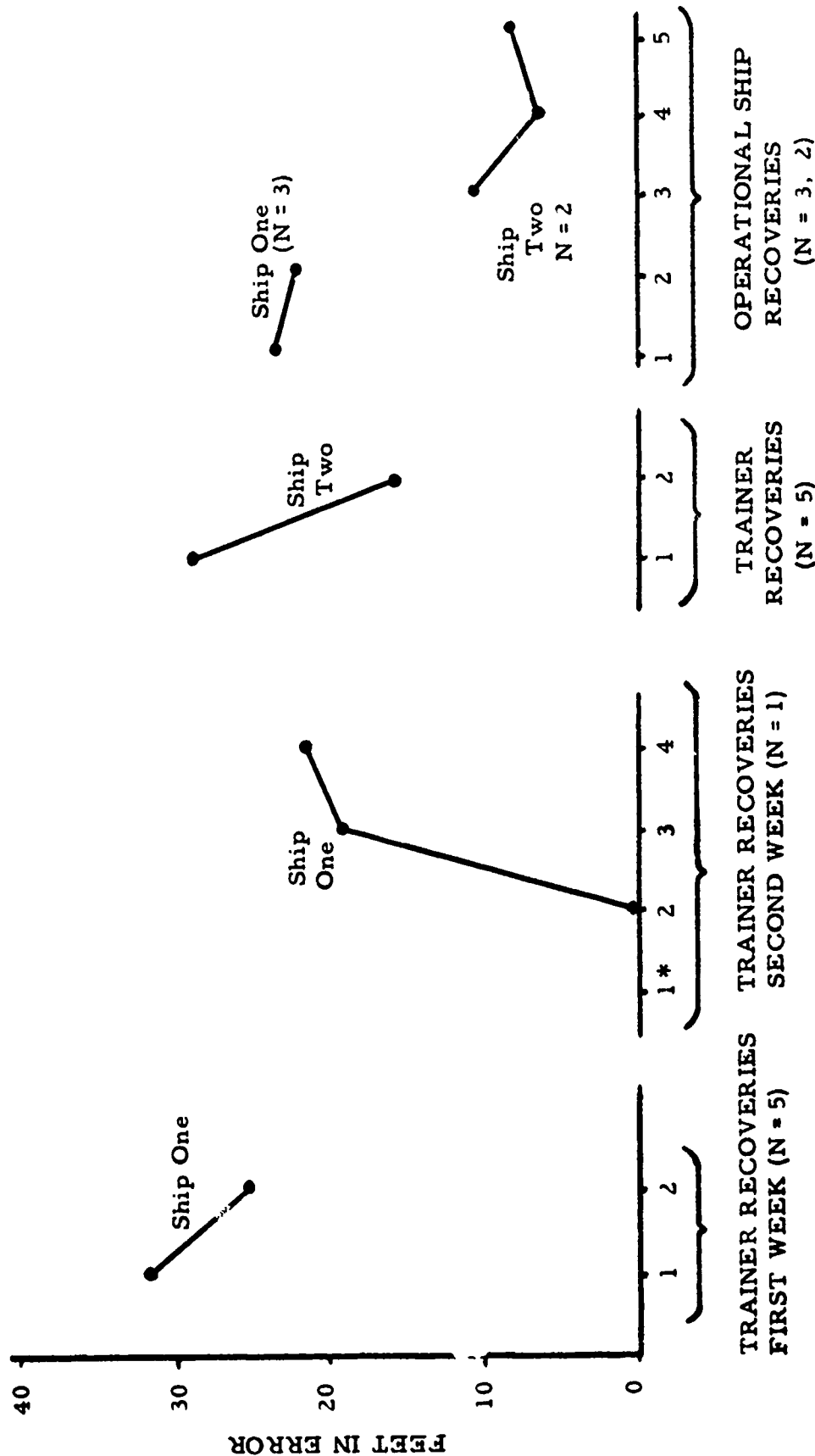
**SUBTEAM\* MEASURE: AIRCRAFT POSITION AT ONE MILE: AVERAGE AZIMUTH ERROR** This measure is defined as the average absolute horizontal deviation of CATCC controlled aircraft from the zero, or perfect, position at one mile from the carrier ramp. The within and across downward trends for curves appearing in Figure 9 indicate reduction in azimuth error as a function of amount of training. Population sizes in each condition (except the second one) are large enough to begin to randomize any effects from individual subteam differences, thereby making extrapolations from the first to the fifth week of training more justifiable. The direction of the considerable difference between operational performance levels for Ships One and Two subteams suggests transfer of training on this measure to the operational environment. The only curve in Figure 9 which appears irregular is the second one ( $N = 1$ ), but when compared to the first curve (the individual curve for this subteam during the first week of training is practically identical to the mean curve), the learning hypothesis is again supported. (The perfect performance on recovery two by that team during the second week can only be considered a random error of good fortune.)

Figure 10 presents data on identical subteams from Ships One and Two to provide a comparison of trainer and ship performances. Figure 10 suggests the training device provides data predictive of operational subteam performance and/or provides subteam training which is transferred to the operational setting.

The standard for acceptable azimuth control of the aircraft at one mile from the ramp is positioning within  $\pm 100$  feet of the glidepath and, with one exception, all the observed subteams performed within this standard during actual operations. In terms of evaluating impact of training on this measure, it is of interest to note that the one exception was controlled by a Ship One subteam which had not trained as a subteam and in which the Approach controller had not received device training. Further, the best Ship One subteam performance during recovery operations was by the one subteam that had trained as a subteam and in which both subteam members had received position training in the trainer (depicted in Figure 10). Comparison of that subteam's operational performance in Figure 10 with the mean Ship One operational performance curve in Figure 9 again provides a basis for suggesting that this aspect of recovery operations effectiveness benefits from device training.

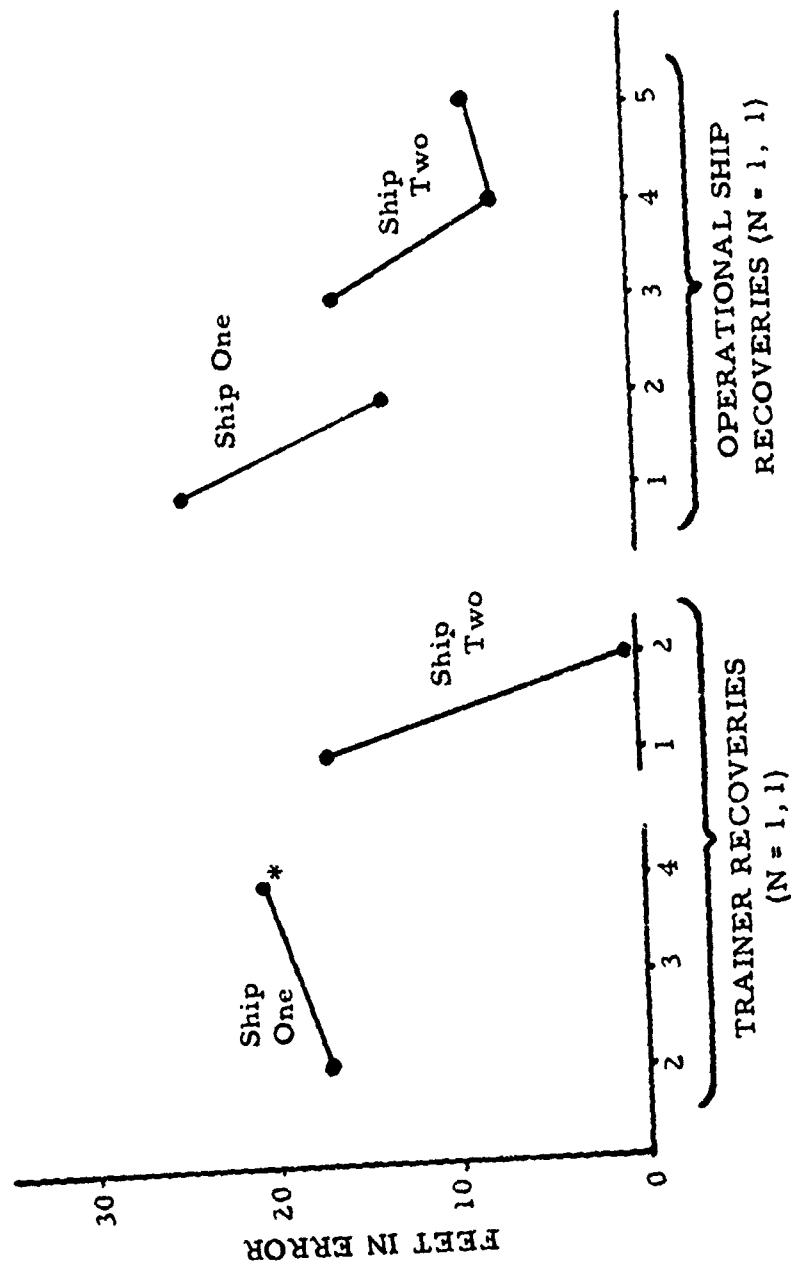
\* A subteam is defined by constant membership with respect to position; e. g., if two controllers exchange Approach and Final positions, a new subteam has been formed.





\* No data on Recovery One. (Incidentally, the individual performance curve for this subteam during the first week of training is practically identical to the mean curve shown.)

Figure 9. Subteam Measure: Aircraft Position at One Mile:  
Azimuth Error



\* NOTE: Data available only on recoveries 2 and 4.

Figure 10. Subteam Measure: Aircraft Position at One Mile:  
Azimuth Error - Comparison of Trainer and Ship Performance  
by Identical Subteams

The parameters of recovery difficulty appeared to influence performance levels on both azimuth and glideslope control but the effect was not entirely consistent. This inconsistency may stem from the need of controllers to employ decision processes during task stress conditions to determine the relative emphasis to be given to each of the control functions. Such decisions are based to some degree on both the state of situational variables (e.g., air traffic situation, sea state, pilot behavior, etc.) and personal experience with these variables. I.e., it is specifically hypothesized that the relative emphasis given to azimuth and glideslope control functions during difficult recoveries may vary as a function of such decision processes.

**SUBTEAM MEASURE: AIRCRAFT POSITION AT ONE MILE: AVERAGE GLIDESLOPE ERROR** Defined as the average absolute vertical deviation of CATCC controlled aircraft from the zero, or perfect, position at one mile from the carrier ramp. Again, the performance improvement trends within the training device environment are quite evident and the population sizes adequate to suggest that training beyond the first week will result in additional improvement in the trainer. The mean curves describing operational recoveries in Figure 11 do not, however, suggest that the additional training improves operational performance on this measure. (Which is not to say that no benefit is derived from training on this measure; evidence suggesting the need for some subteam training is discussed in the next paragraph.)

The operational standard for acceptable glideslope control at one mile from the ramp is aircraft positioning within +100 to -50 feet of the glidepath. All of the subteams performed acceptably with respect to this standard with one exception; two approaches were below -50 feet and these were controlled by the same Ship One subteam which had also performed unacceptably on azimuth control.

The best Ship One performances (average error = 12 feet) were by two subteams both of whose members had received device training. One pair trained together as a subteam while the other did not. The rest of the Ship One performances were much poorer (average error = 25 feet) and were by subteams containing a member who had not trained in the device. From this evidence it appears that acceptable operational performance is more likely if at least one week of subteam training has been received.

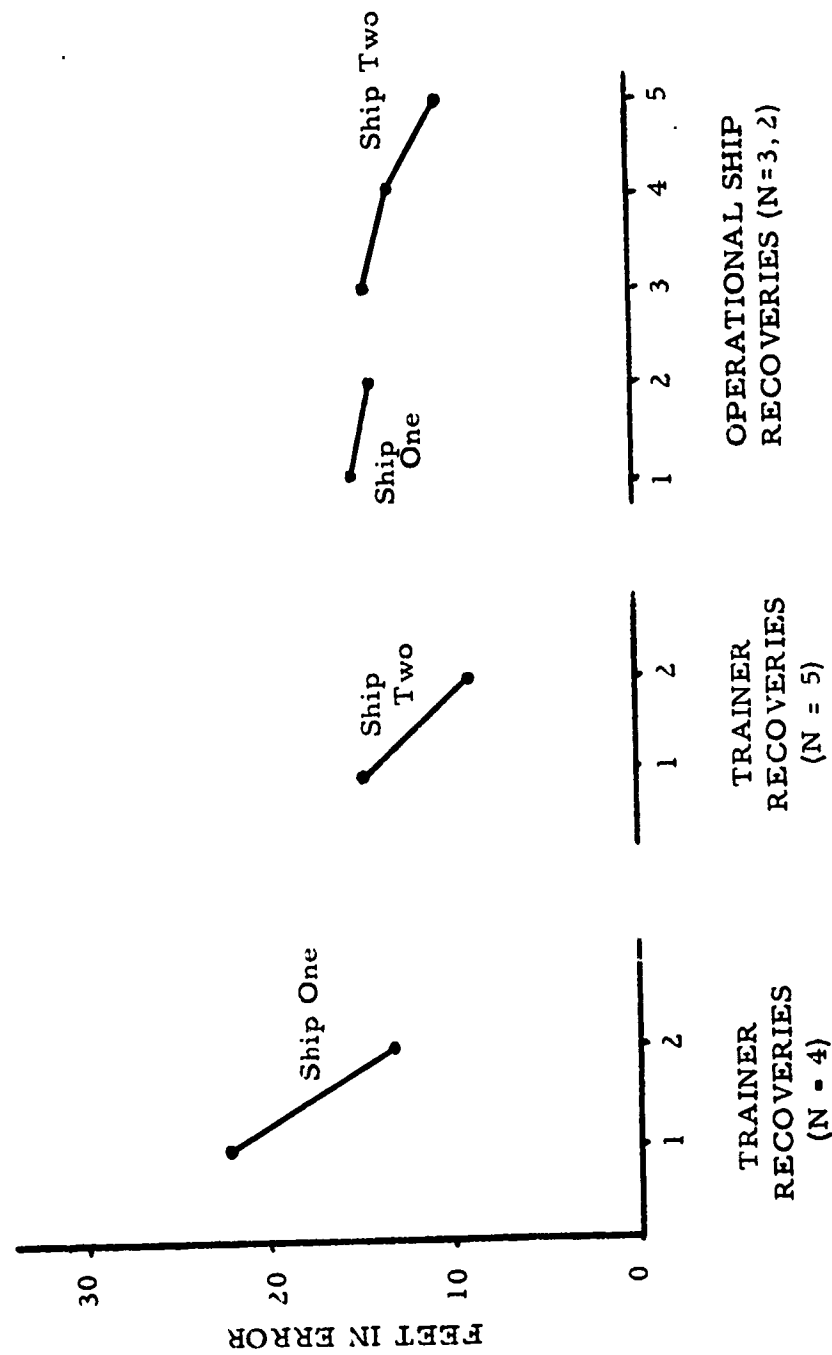


Figure 11. Subteam Measure: Aircraft Position at One Mile: Glideslope Error

It is of some interest to review figures 9 and 11 and compare the azimuth and glideslope error magnitudes. First, it can be observed that glideslope errors tend to be smaller than azimuth errors in the trainer environment. The same is true for operational performance by Ship One subteams. This might be explained by the fact that glideslope deviation is more critical both with respect to probability of trapping (due to the geometry of the situation, glideslope deviations result in larger impact point deviations) and accident probability (an aircraft much below glideslope may strike the ramp). This greater criticality may result in greater attention on the part of the controller and, possibly, more stringent training in earlier training phases.

Second, it can be observed that the subteam glideslope errors for Ship Two operational recoveries are larger than their azimuth errors but that their mean performance levels are not markedly different from those for Ship One, nor from what they attained in the trainer. From this and the training discussions above, it follows that a 10 to 11 foot average glideslope error may be the reasonable and attainable performance standard when controlling an average pilot population.

**SUBTEAM MEASURE: COMMUNICATIONS EFFICIENCY** The two communications measures (Efficiency and Noise Level) differ from the other measures in that they are judgments made by instructor personnel using a graphic rating scale. Communications efficiency is defined as the transmittal of maximum information content in a minimum amount of time which is understandable by and necessary to the pilot under control. The standard of comparison utilized by these personnel for the top end of the scale was that communications efficiency level which had been observed for very good, operationally experienced, control teams. The only unusual data reduction procedure utilized on this measure was to separate ratings made by instructor personnel from those made by Bunker Ramo personnel. This was considered advisable in that while all of the instructor personnel possessed extensive operational and training backgrounds on which to base their criterion definition and use of the scale, Bunker Ramo personnel did not.

As can be seen by reference to Figure 12, Communications Efficiency improved within and across training conditions. It was also found that variations in communications efficiency tended to result from changes in recovery difficulty and, in fact, to be sensitive to somewhat finer distinctions between difficulty levels than appeared to be the case with the previous measures.

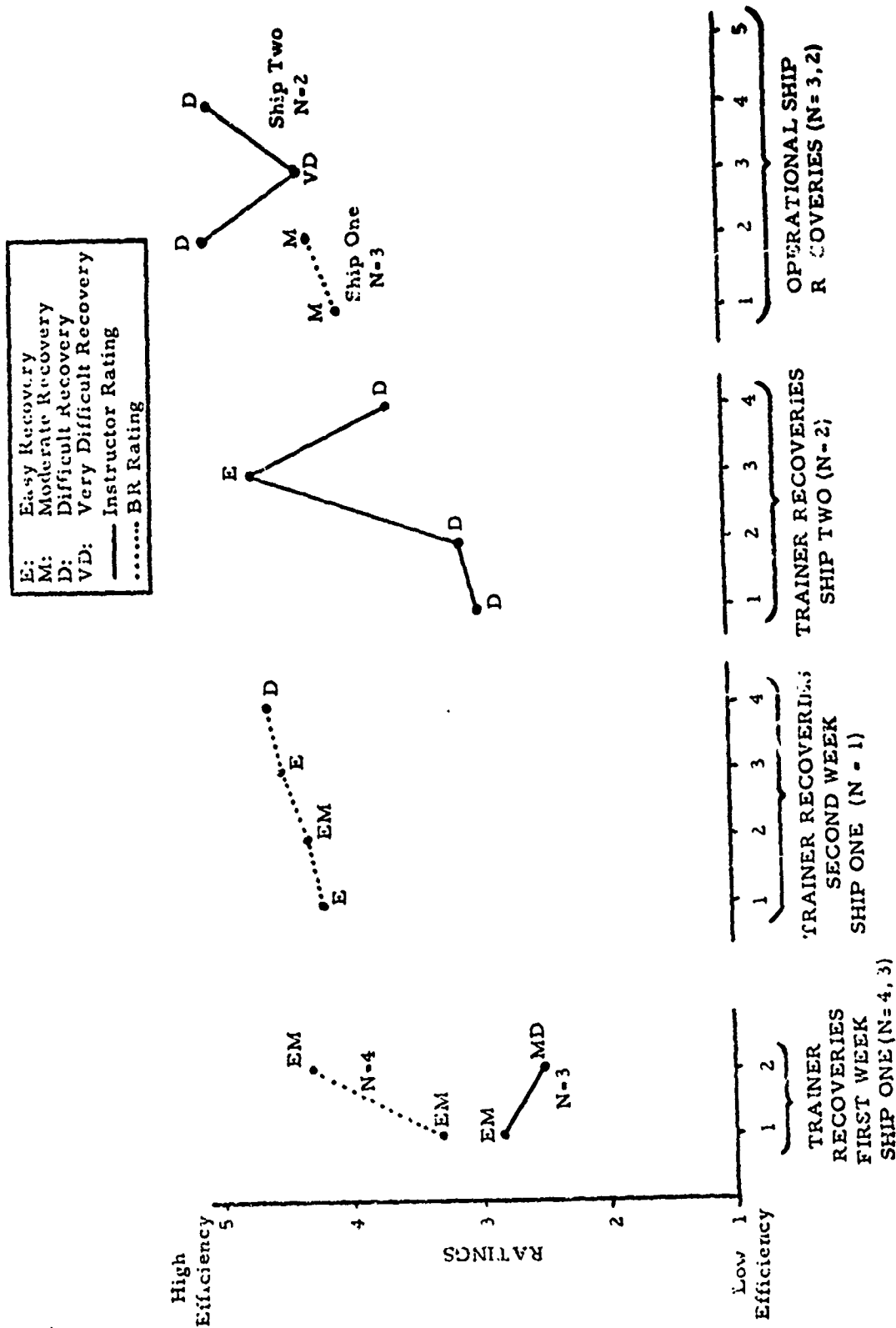


Figure 12. Subteam Measure: Communications Efficiency

Unfortunately, no firm evaluations can be made regarding transfer due to the introduction of a new variable, instructor vs. Bunker Ramo judgment. (Operational performances of the two ships may have differed as a function of this variable rather than amount of training differences.)

Based on the operational performance curves in Figures 12 and 13, it can be said that operational communications efficiency was judged to be more than adequate even though some of these recoveries were performed with only one primary approach frequency. And the following can be noted regarding operational performance of individual subteams: (1) the Ship One subteam receiving the lowest operational rating (3.7) was one including an "untrained" approach controller. The lower rating resulted from the judgment that this member of the subteam communicated more than necessary or desirable, (2) The Ship Two subteam receiving the lower ratings (3.5 to 5.0) was the one which had not trained in the device as a subteam and in which the approach controller had had the least amount of training (one week). This controller was faulted by some pilots for not communicating enough information. So the evidence does suggest that operational subteam communications efficiency is better if device training has been received, even though it is not conclusive.

#### TEAM, SUBTEAM MEASURE: COMMUNICATIONS NOISE LEVEL

Defined as the level of noise generated in the subteam or team working area due to communication which is beyond that level generated by normal use of the primary approach frequencies. Again, a graphic rating scale was used with a standard of comparison as described above for communications efficiency. Data collected on the Ship Two crew assessed subteam noise level. Due to developments of somewhat different coordination procedures, the Ship One crew was best evaluated at the team level on this measure during the first week of training. The team ratings were made entirely by instructor personnel.

The same comments made for Communications Efficiency improvement within and across training conditions and apparent sensitivity to recovery difficulty can be made for Communications Noise Level (see Figures 14 and 15). The only deviant curve appears in Figure 14 and describes the second week of training for one subteam from Ship One. It is possible that this curve, if reflecting accurate judgments, may be primarily a function of situational stresses, partially described by recovery difficulty levels.

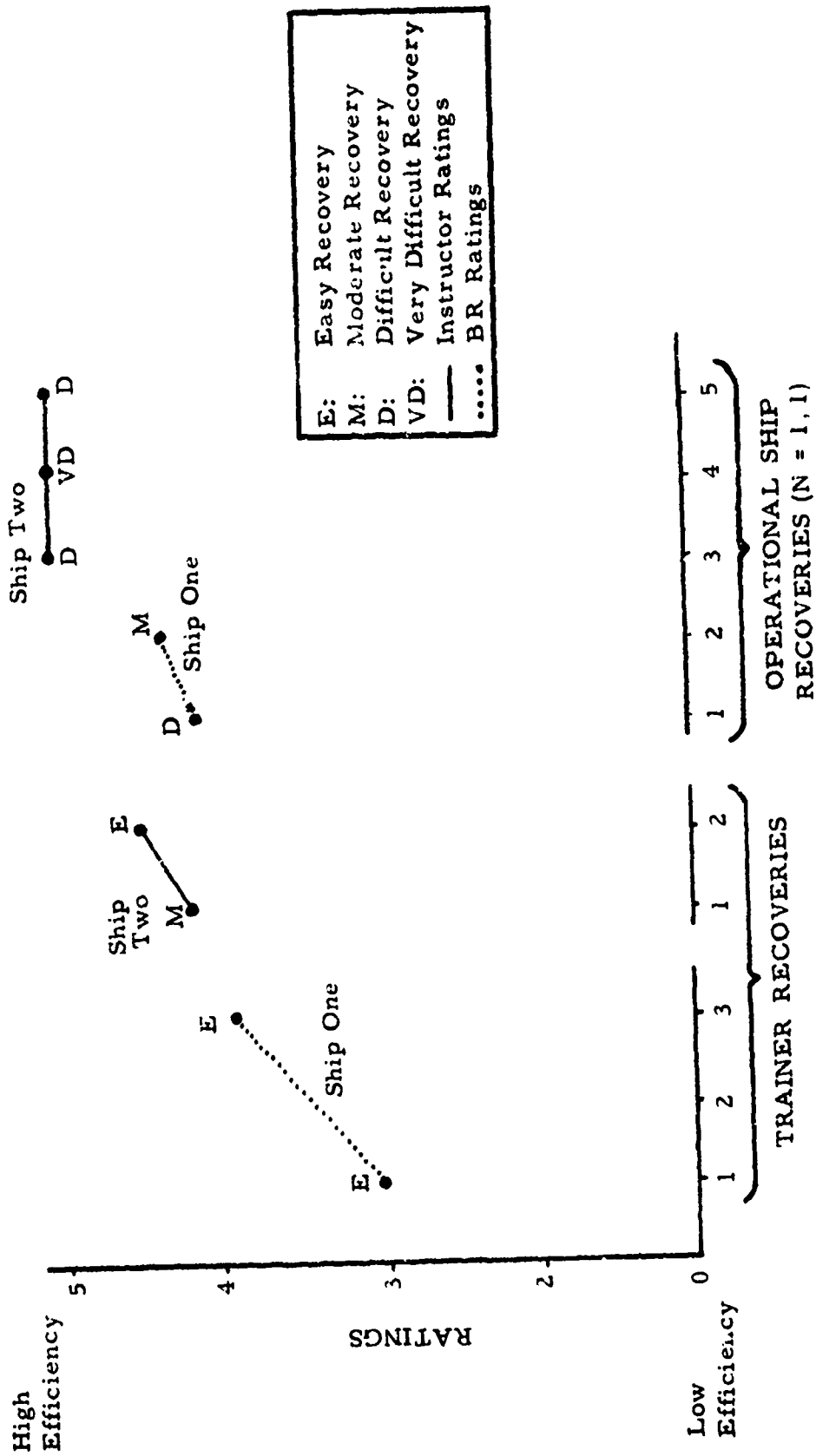


Figure 13. Subteam Measure: Communications Efficiency - Comparison of Trainer and Ship Performance



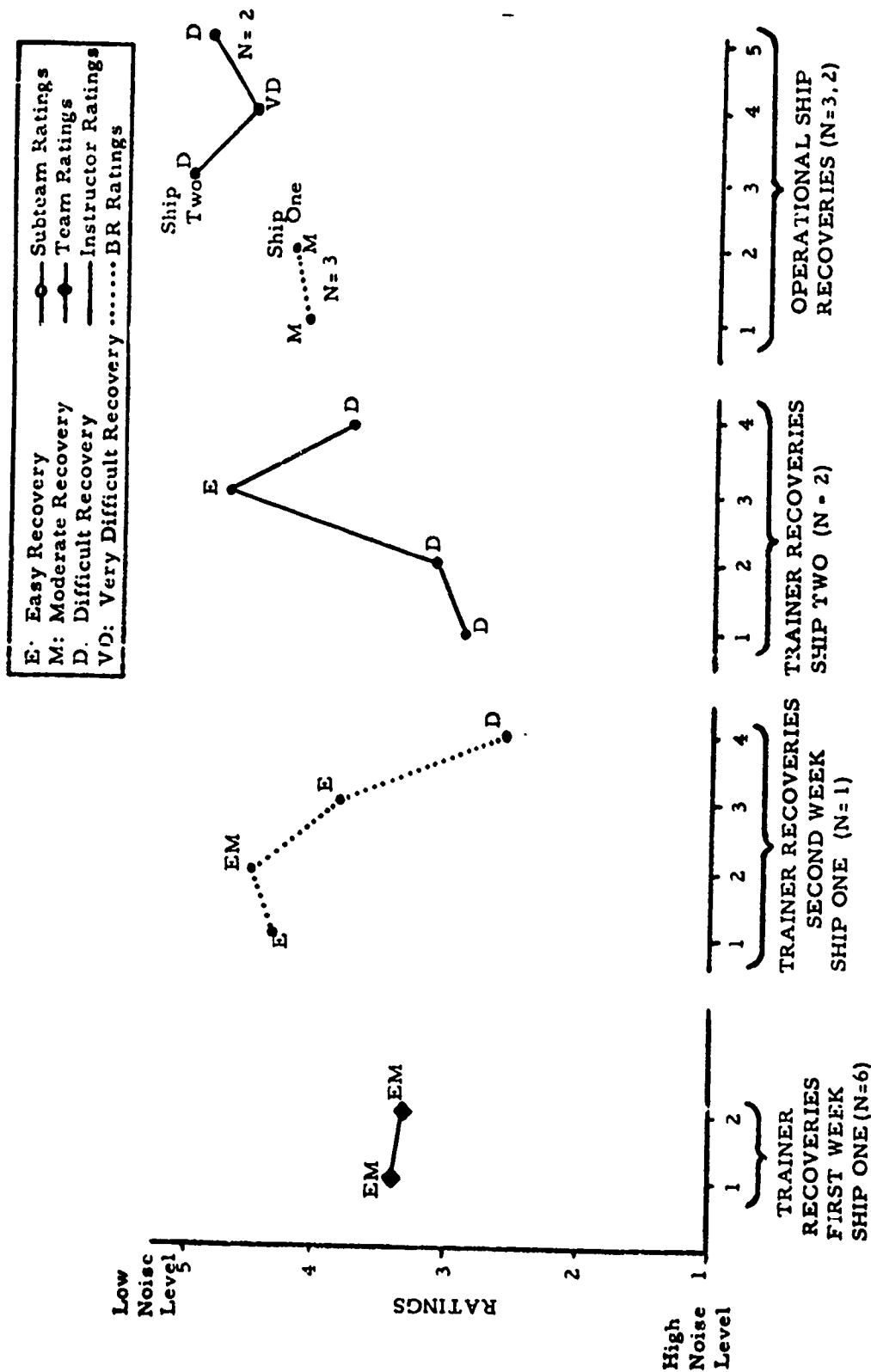


Figure 14. Team, Subteam Measure: Communications Noise Level

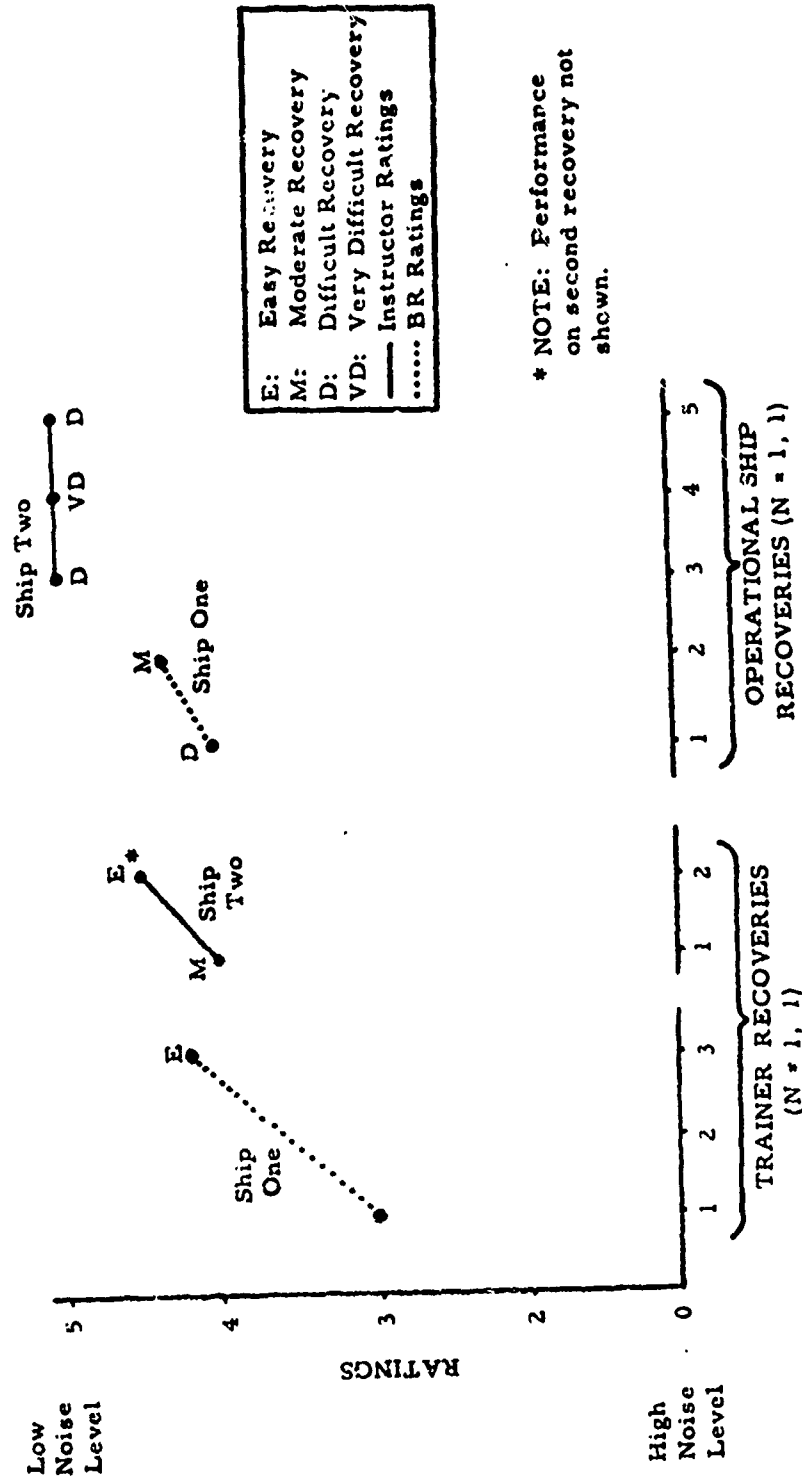


Figure 15. Subteam Measure: Communications Noise Level- Comparison of Trainer and Ship Performance by Identical Subteams

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Again, as with Communications Efficiency, no firm conclusions can be drawn regarding transfer of training. The same comments made for Figures 12 and 13 can be made for Figures 14 and 15. Again, operational noise level was very good on Ship Two, with the subteam which had not trained as a subteam receiving the lower ratings (4.0 to 5.0). All the Ship One subteams received adequate but lower ratings, reflecting the higher noise levels heard on this ship.

**INDIVIDUAL MEASURE (APPROACH, FINAL): RADAR CONTACT NOT ANNOUNCED TO PILOT** Defined as the percentage of the total number of radar contacts that should have been announced to pilots which were not announced; i. e., it is an error measure for a standard communications procedure. Communications and equipment utilization procedures are trained in the device to the extent inadequate performance of these procedures is observed by the instructors; therefore the amount and type of procedural training given in the device is a function of crew requirements for such training. An opportunity for evaluating the value of the training device for procedural training arose when instructors observed that the Ship Two teams (the first teams observed during this investigation) were not always announcing radar contacts to the pilots. They suggested that a measure of this behavior be collected. The improvement in procedural communications performance on the part of individual controllers from both ships can be seen in Figure 16. Operational performance by individual controllers on Ship One was error free. Ship Two controllers purposely did not announce radar contact to the pilots due to poorly functioning radars during the observed recoveries; this represented a consciously executed and correct performance of this procedure.

**INDIVIDUAL MEASURE (APPROACH, FINAL): USE OF PRIMARY APPROACH FREQUENCY WITHIN 1/2 MILE OF RAMP** Use of this frequency by either the Approach or Final controller when one of their aircraft is traversing the interval between 1/2 mile out and the ramp is to be avoided due to possible conflict with LSO communications. Use of the channels during this interval was relatively infrequent and, with one exception, the Approach controller was the party responsible. Use was generally the result of situational necessity. It would appear from the data that the observed controllers understood and were able to perform with respect to this criterion acceptably from the start of device training, and subsequently, in the operational environment. As no trends were apparent, the data is not displayed graphically. In terms of device evaluation, it can only be said that the device provides the instructors with an opportunity to monitor students performance with respect to this

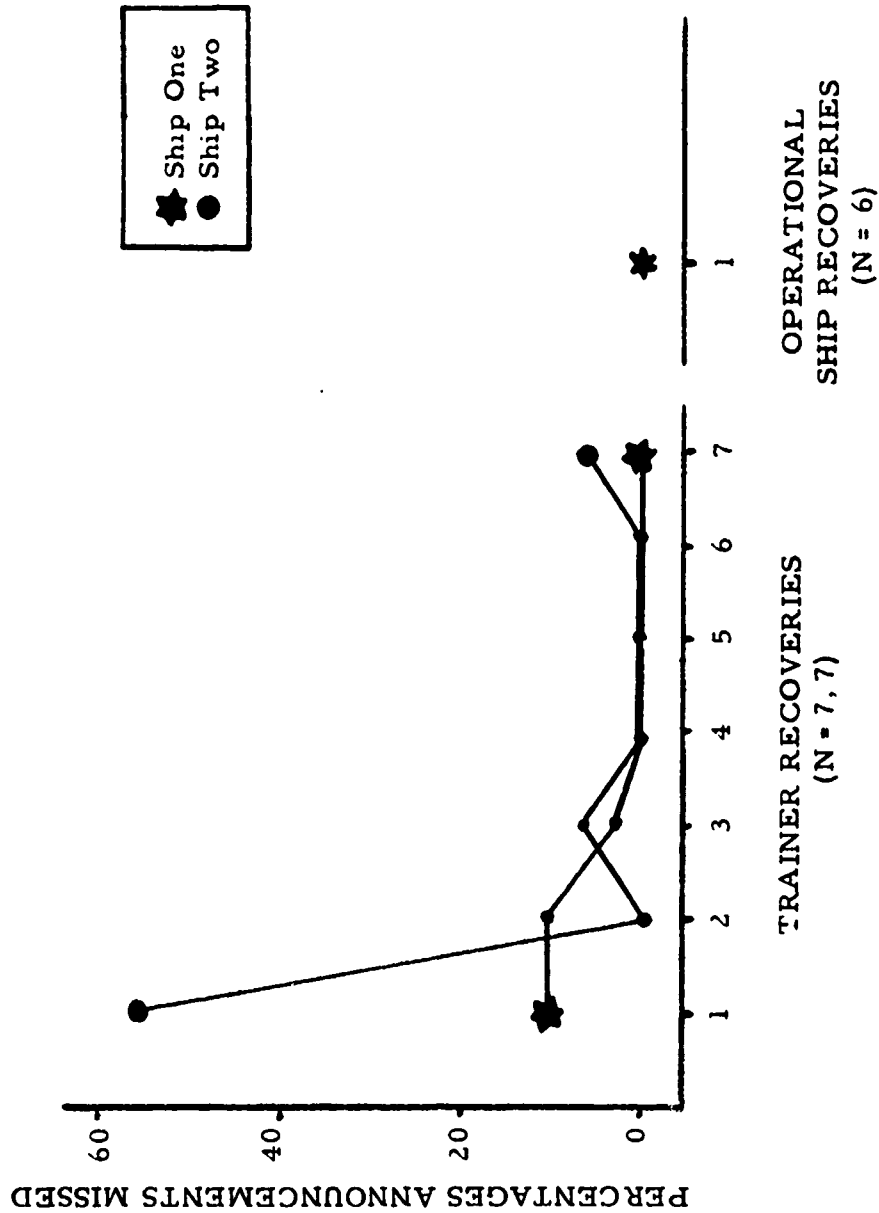


FIGURE 10. INDIVIDUAL MEASURE (APPROACH, FINAL):  
RADAR CONTACT NOT ANNOUNCED TO PILOT

aspect of communications behavior. It would therefore be expected that, as was the case with the previous measure, if individual controllers are observed using the primary approach frequency unnecessarily during this interval then the device provides an opportunity for corrective training.

#### INDIVIDUAL MEASURE (APPROACH): NUMBER OF CONFLICTIONS

A confliction has occurred when aircraft come within unacceptably close distances of one another, whether or not they actually collide. This is an especially critical measure - in terms of both life and equipment costs - but a difficult one to reasonably display or discuss quantitatively due to its seldom occurrence (unless much larger data samples are available than obtained in this study). Instead, textual descriptions of the observed conflictions are presented below to provide the information needed for evaluation purposes.

##### a. Trainer Recoveries

- (1) SHIP ONE: One confliction was caused by both Approach controllers during the first week of training. One controller froze (didn't communicate with either the pilot or the other approach controller) while the other controller made poor control decisions when the confliction situation began developing. This was an easy recovery using two minute separations, but it was the third recovery using NTDS symbology. The crew did not attempt to use the symbology again during subsequent training.
- (2) SHIP ONE: One confliction was caused by one Approach controller on his first day of training and third recovery in this position. It was caused by poor execution of the integration function.
- (3) SHIP ONE: Three conflictions on two recoveries in sequence on the same day were caused by the same Approach controller during his second week of device training (performance during his first week of training was not observed). Decision was made not to use this person as a controller based on this and other aspects of performance.
- (4) SHIP TWO: Two conflictions in separate and difficult problems were caused by the same controller. Other device

and operational measures of performance on this controller indicate he is one of the better Approach controllers. Of relevance here is his expressed opinion that the trainer is the place to test capability limits and to try out alternative solutions, "because in the trainer you won't kill anybody".

b. Ship Recoveries

- (1) SHIP ONE: Appears to have been one or two conflictions (or at least situations which were dangerously close in both the pilot and another controller's opinion). The faulted controller did not receive approach control training in the device.
- (2) SHIP TWO: One confliction, caused primarily by intermittently operating radar. It appears, however, that the situation may have been initially set up by the Approach controller who had received only one week of device training.

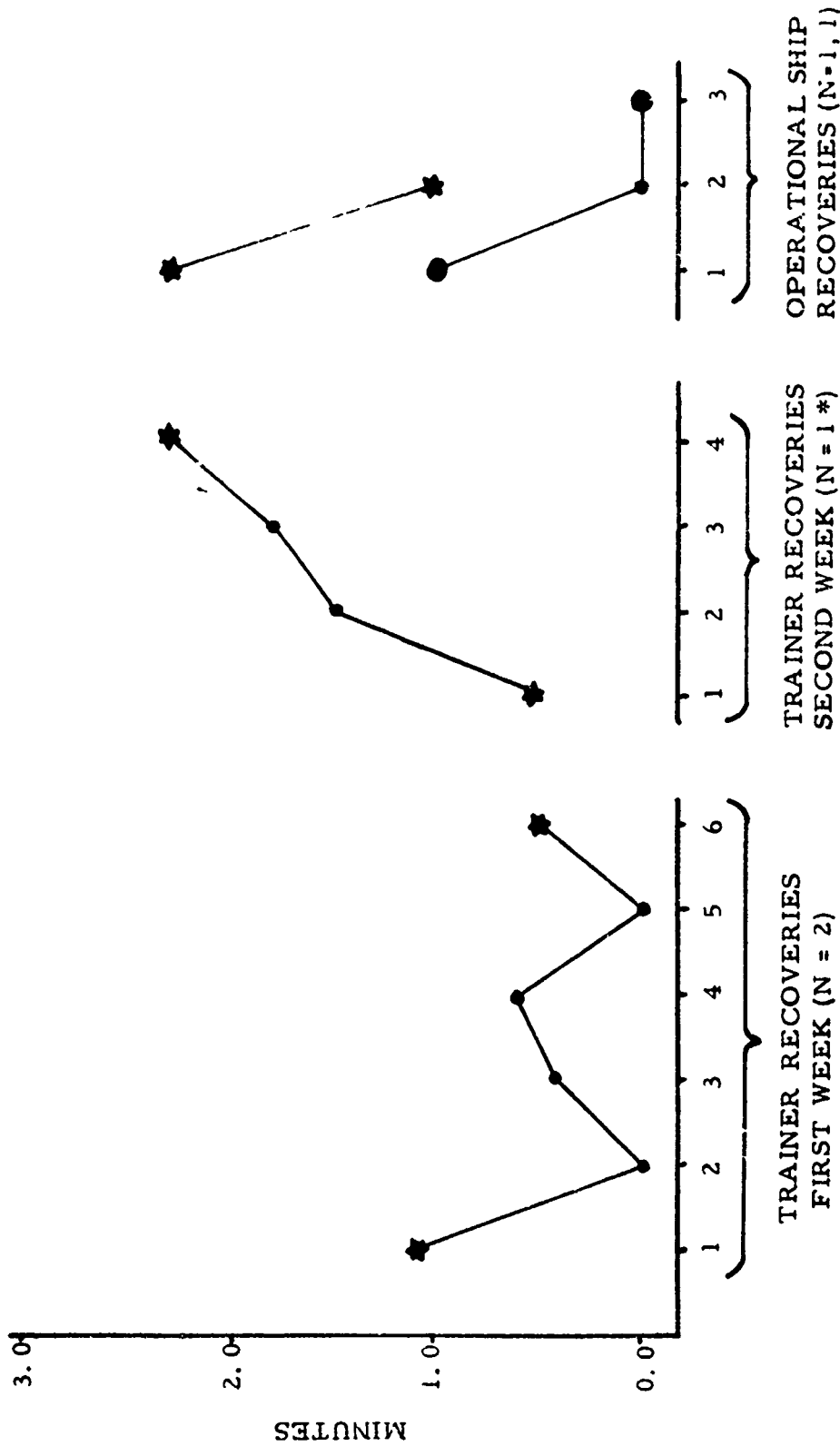
Based on the above descriptions and the extreme criticality of this measure, it appears the following should be said: (1) Inexperience can lead to conflictions in the training device (see a. (1) and (2) above), (2) If training device performance and behavior is similar to operational performance and behavior (and the objective data and observations support this), then personnel evaluation and selection based on training device performance will reduce the likelihood of conflictions during actual CATCC controlled recoveries (a. (3)), (3) The device may be valuable, not only for developing proficiency, but also for evaluating limits and alternative solutions (a. (4)), and (4) The likelihood of conflictions in the operational environment is affected by training in the CATCC training device (b. (1) and (2)).

INDIVIDUAL MEASURE (APPROACH CONTROLLER IN SUBTEAM A):  
DEVIATION FROM SCHEDULE RAMP TIME FOR FIRST AIRCRAFT

Defined as the difference, in minutes, between the time the first aircraft reaches the ramp and the time the ramp is scheduled to be open. Measured whenever the time of arrival can be attributed to the Letdown controller rather than other events (e. g. , Marshaller error, unannounced heading change just prior to ramp time).

Based on the curves presented in Figure 17, it must be concluded that Ship One Approach controllers did not improve their performance on this measure while in the training device (other Ship One data, not

◆ Ship One  
 ● Ship Two



\* Data on this individual is not included in the First Week curve.

Figure 17. Individual Measure (letdown A): Deviation From Scheduled Ramp Time for First Aircraft

included in Figure 17 due to incomplete samples, also failed to indicate learning). In contrast to Ship One, data for Ship Two Approach controllers (again, cannot be presented graphically due to incomplete samples) describe perfect performances (zero deviations) on five of the seven measurable recoveries. Of the two missed ramp times, one was controlled by a controller in the Approach position for the first time (1.5 minute miss) while the other was confounded by situational events. The operational data describe the Ship One controller who did not receive training in that position in the device and the Ship Two controller who had received only one week of device training.

It is unclear from the above discussion whether or not the training device is effective for training this aspect of performance. Based on observation, overall similarities between recoveries, and discussion with instructor personnel, it is suggested that Figure 17 is indicative of device utilization, rather than device capability. CATCC crews are given classroom instruction in the importance of meeting ramp times and how to meet this criterion. Instructor personnel indicate that if ramp times are missed to any extent or consistently this is pointed out to the controllers and corrective instruction given. In the case of Ship One, however, there were a number of other personnel and coordination problems of much greater importance which required resolution insofar as possible during the training period. In other words, it is suggested that performance by Ship Two Letdown A controllers represent training device capability, while performance by Ship One Letdown A controllers represent a case of training device utilization.

**INDIVIDUAL MEASURE (MARSHALLER): MARSHAL INFORMATION BROADCAST: COMPLETENESS AND ACCURACY** During the marshalling period, the marshaller is responsible for communicating a standard set of informational items to each of the pilots. This is accomplished both by communications to individual pilots and by general information broadcasts. Ship One Marshallers were monitored periodically, especially during the first week of training. No errors (100% accuracy) or omissions (100% complete) were observed. Due to manpower constraints, data were not collected on this measure on board Ship One. A Ship Two Marshaller made one error on the first day of training which complicated that recovery. From that point on, no omissions and no further errors were observed. Data collected on board Ship Two indicates 100 percent accuracy and completeness for Marshaller broadcasts.



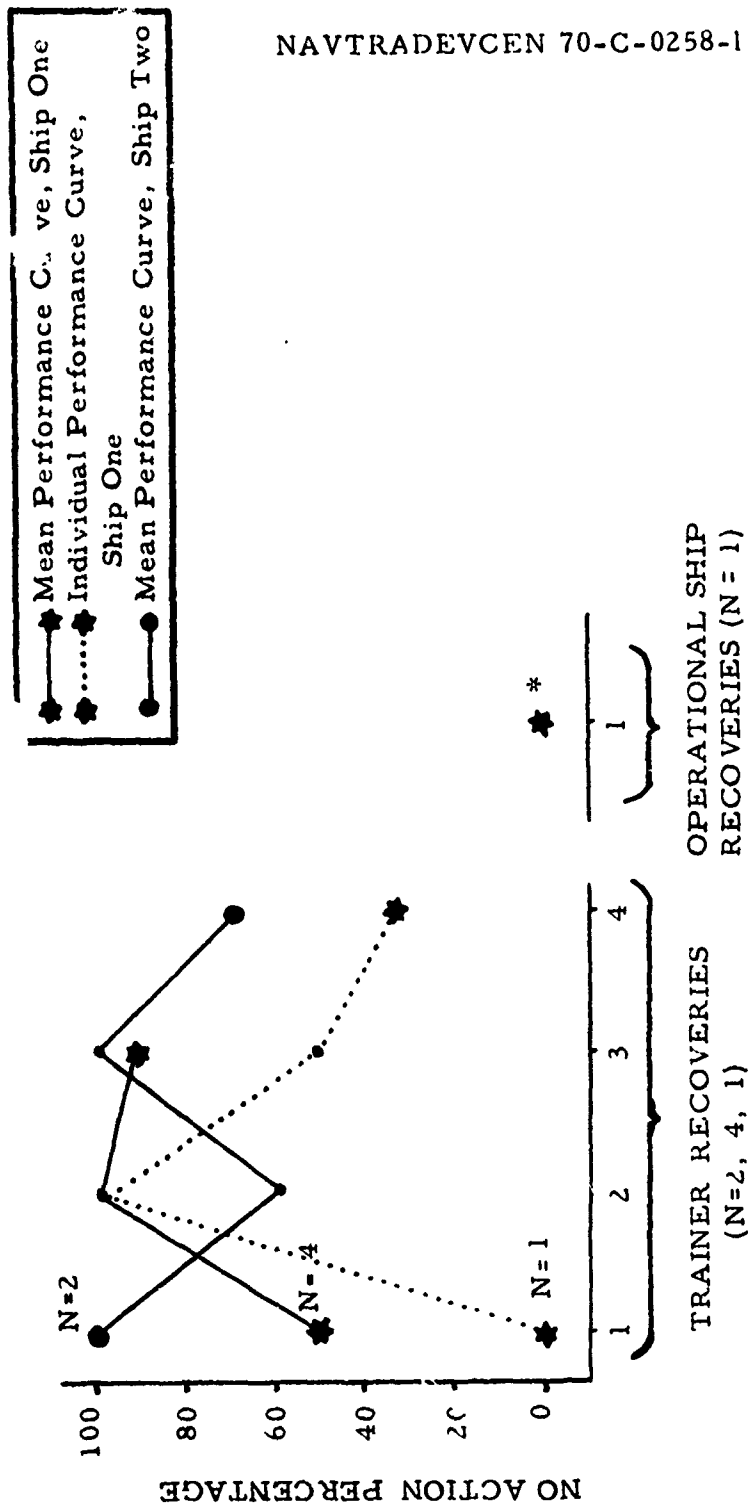
The conclusion regarding trainer utility is that it provides an opportunity for corrective instruction if such is needed. If a broadcast error or omission is made, the students are provided with an opportunity to realize the possible effects of such errors and omissions. The primary value of the trainer for this activity appeared to be the opportunity it provided the Marshalls and Marshal Status Board Keepers for developing coordinated procedures which would avoid errors and omissions. Broadcast errors and omissions were made, especially early in training, but were not scored as such because they were caught and corrected by these personnel. It was observed that, as a result of these errors and omissions, procedures were purposely developed by the students to avoid their recurrence.

**INDIVIDUAL MEASURE (MARSHALLER): EAT DEVIATIONS BEYOND EAT  $\pm$  .25 MINUTES NOT ACTED ON** Defined as the percentage of incidences not acted upon by the Marshaller. An incident occurred whenever a pilot did not depart the marshalling area within  $\pm$  .25 minutes of his assigned EAT. As an incident did not occur in every recovery, only those recoveries having such events were considered for this measure (i. e. , Trainer Recovery No. 3 in Figure 18 is the third recovery in which each of the Marshalls experienced this type of problem).

It does not appear, based on the curves presented in Figure 18, that the student Marshalls tended to improve this aspect of their performance as a result of trainer use. The only student Marshaller exhibiting what might have been a learning trend was the Ship One student Marshaller who later performed in this position onboard the carrier (see Figure 18, Individual Performance Curve, recoveries 2-4). This Marshaller did act correctly on the one incident occurring during observed Ship One operational recoveries.

The Ship Two Marshaller who performed in this position during operational recoveries used a self-defined criterion of EAT  $\pm$  1.00 minute during trainer recoveries; corrective instruction was not given. What EAT criterion this marshaller used onboard is not known; observation of operational behavior and interviews indicated, however, that he had become aware of time as an important criterion with respect to Marshal control activities.

Based on the data, it appears that one Marshaller may have learned to perform with respect to the EAT criterion as a result of device training. None of the other Marshalls exhibited any consistent improvement



\* The performance of this same individual in the training device is represented by the individual performance curve.

Figure 18. Individual Measure (Marshall): EAT Deviation Beyond EAT + .25 Minutes Not Acted On

while in the device. From this evidence it must be concluded that positive effects on this aspect of Marshaller performance as a result of device training appear doubtful and it should be questioned whether this apparent lack of consistent performance improvement is the result of training device capability or utilization. Based on a review of device capabilities, student responses to queries regarding the EAT criterion, and observation, it appears that Figure 18 reflects training device utilization and the following suggestions can be made:

- a. The mission clocks within the mockup should be synchronized with PC & E program time. Some student marshallers indicated a reluctance to take action on any but extreme EAT deviations due to suspicions that PC & E time was not synchronized with their mission time. The result was that even extreme deviations were missed. These suspicions arose when aircraft consistently departed Marshal with an EAT deviation of similar magnitude. This suggestion can be easily implemented by more careful setting of the mission clocks (these are reset at the start of each trainer recovery).
- b. Use EAT deviations on a more systematic basis as determined by student performance. The time of departure from marshal is controlled by PC & E pilots who are working under instructor supervision. It appears from the collected data that EAT deviations occurred randomly; that is, they were not used as an instructional tool for either this aspect of Marshaller performance or the development of coordinated team procedures for EAT deviations. It is suggested that the Marshaller's EAT deviation behavior be monitored more closely and that deviations be inserted into the problems as needed to train Marshaller and team performance to acceptable levels.
- c. Provide corrective instruction when EAT deviations are not acted upon. As this is not one of the more important training objectives (conducting a safe recovery under difficult conditions is the primary training objective) and EAT deviations can disorganize recoveries to such an extent that they become poor vehicles for the other training objectives, it is important that EAT deviations not be used more than is realistic or is necessary for Marshaller and team coordination training. The instructional effect of EAT deviations will be increased (so that fewer need be used) to the extent that corrective instruction is given by the instructors when the student Marshaller fails to act appropriately.

**EVALUATIVE PERFORMANCE MEASURES** It will be recalled that evaluative performance data were collected from student controllers, pilots, LSOs and the ORI team. The purposes of these data were both to establish the adequacy of controller performance during operational recoveries and to provide explanatory background information which would assist data interpretation and device evaluation efforts.

**CONTROLLER SELF-EVALUATIONS** The student controllers were asked to evaluate their own performance with respect to Communications, Guidance, Emergency Procedures, Contingency Handling, and Overall Performance using three and five point scales. They made the same set of evaluations twice, once within the training device and once onboard the carriers. The evaluations were made in the trainer at the midpoint of the observed training periods. At sea the evaluations were made between or after observed recoveries. The results presented in Figure 19 indicate that the controllers generally evaluated themselves as performing at Good to Excellent levels during operational recoveries and that their operational performance was judged to be better than their trainer performance. These results are as one would predict if the trainer is hypothesized to provide rigorous training which prepares the student to perform adequately in the operational environment.

It is of interest that the only two individual operational performance evaluations which were lower than their trainer evaluations were both made by comparatively inexperienced and young controllers (Approach and Marshal positions) in the Emergency Procedures category. As stated earlier, instructor personnel feel that their most important training objective is to prepare teams to conduct safe recoveries under difficult conditions. One of the frequently used problem variables is that of aircraft emergencies and contingencies. The responses by these controllers, in particular, indicates that encountering these problems during actual recoveries is indeed difficult and requires preparation.

It is also of interest to note that the greatest difference between Trainer and Ship self-evaluations takes place in the Guidance category. This difference will be relevant to the discussions of evaluative training device measures (pp. 81-82).

**PILOT EVALUATIONS OF CATCC PERFORMANCE** Pilots participating in the observed operational recoveries were requested to complete an evaluation form for the Marshal, Approach, and Final controllers with respect to Communications, Guidance, Emergency Procedures, Contingency Handling, and Overall Performance using a three point scale. The

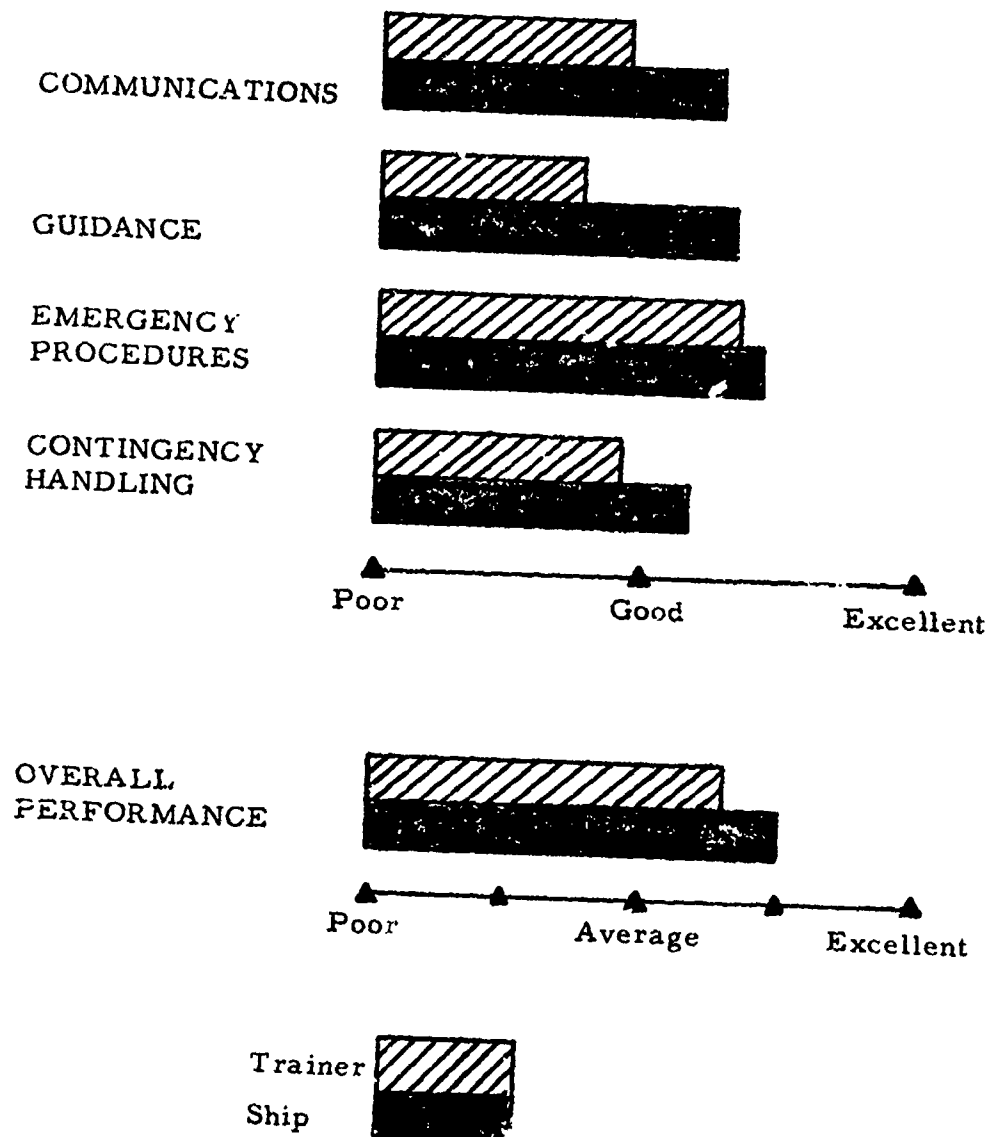


Figure 19. Controller Self-Evaluation: Comparison of Trainer and Ship Performance Evaluations

form also allowed evaluation of overall team performance on a five point scale and provided an opportunity for comments, explanations and suggestions. As indicated by the results in Table 5, the controllers in each of the positions were judged between "good" and "excellent" on each of the tasks by the pilots under their control. It will be noted that Guidance received the lowest evaluations; again, this will be discussed in greater detail later (pp. 81-82). The mean team rating was 3.8 (between "average" and "excellent") which indicates the pilots felt that the overall team performance was also quite adequate.

**LSO EVALUATIONS OF CATCC PERFORMANCE** LSOs who performed during the observed recoveries were interviewed. CATCC performance was judged adequate by these personnel on both Ships One and Two.

**ORI TEAM EVALUATIONS OF CATCC PERFORMANCE** The results of ORI conducted on both Ships One and Two indicate quite adequate performances in both instances.

**EVALUATIVE TRAINING DEVICE MEASURES** Student controllers and instructor personnel completed training device questionnaires which required device evaluation from three standpoints: (1) Task environment realism, (2) Task performance realism, and (3) Training effectiveness (see Figures 20 through 22). Other questions were asked regarding NTDS symbology and additional effective or ineffective characteristics.

The rating responses to questionnaire items are displayed in Figures 20 through 22 for five populations: (1) Ship One student responses during training, (2) Ship Two status board keepers during training (responses made by this crew's board keepers were distinctly different in many cases from those made by the controllers, making separate displays advisable), (3) Ship Two student controllers during training, (4) Ship Two student controllers during onboard operations, and (5) Instructor personnel.

To provide an overall perspective, three general data trends can be pointed out:

- a. The CATCC training device generally received moderate to high ratings on both realism and effectiveness (Figures 20-22 and Table 6).
- b. The CATCC training device generally received higher ratings on effectiveness than on realism (Figures 20-22 and Table 6).

TABLE 5. PILOT EVALUATIONS OF CATCC PERFORMANCE

PERFORMANCE VARIABLES	CATCC POSITION			MEAN EVALUATION
	MARSHAL	APPROACH	FINAL	
Communication	2.2*	2.1	2.1	2.1
Guidance	2.6	2.0	1.9	2.0
Emergency Procedures	2.6	2.3	2.2	2.4
Contingency Handling	2.1	2.1	2.4	2.2
Overall Performance	2.2	2.0	2.0	2.1
Mean Evaluation	2.2	2.1	2.1	2.1

\* Values of 1, 2, or 3 assigned to pilot selection of Poor, Good or Excellent on a rating scale.

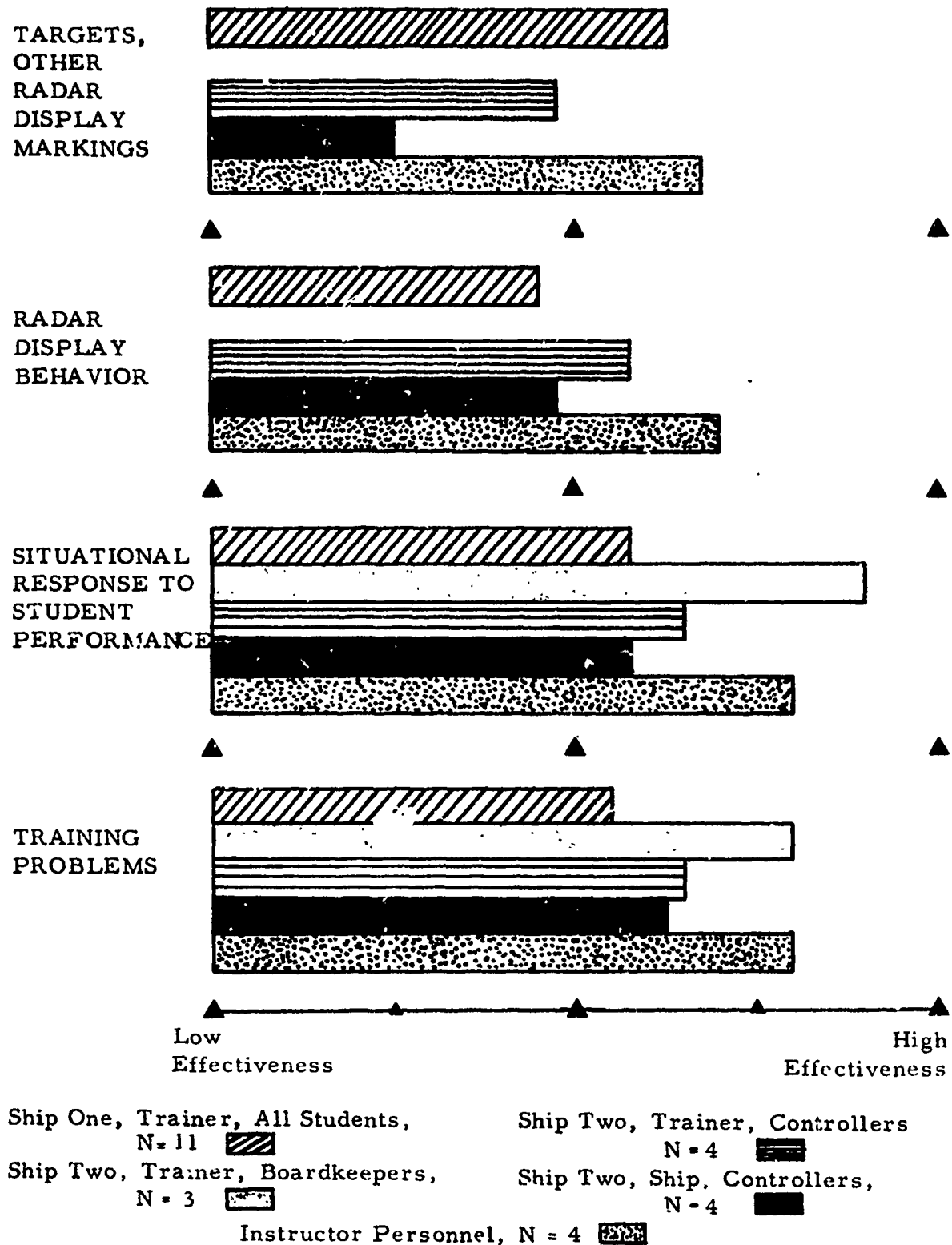
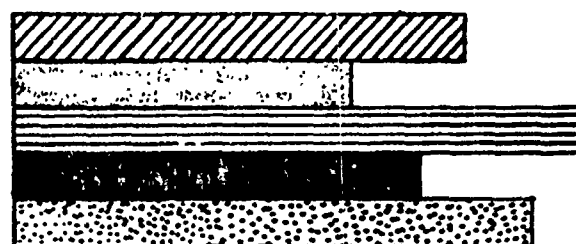


Figure 20. Trainer Evaluations: Task Environment Realism  
(N = 11, 3, 4, 4, 4)

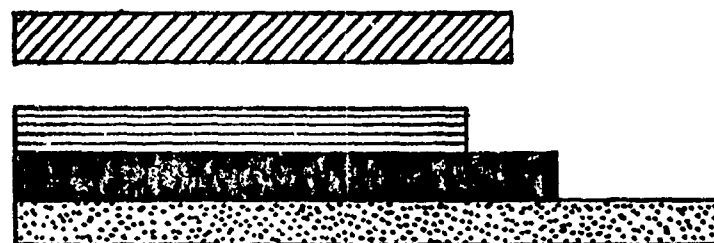


NOTE: See previous figure for legend.

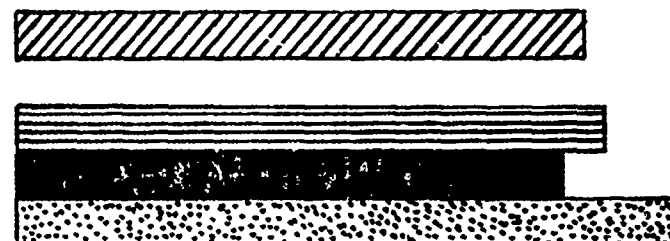
## COMMUNICATION



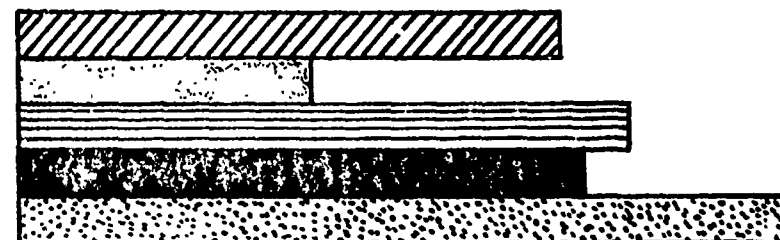
## GUIDANCE CONTROL



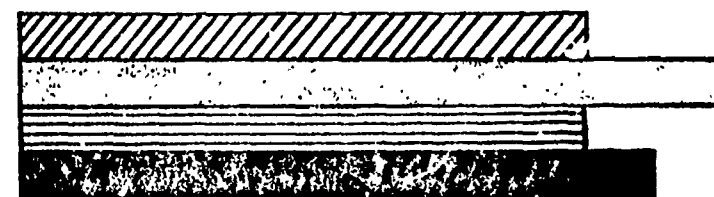
## CONTINGENCY HANDLING



## EMERGENCY SITUATION



## STUDENT PERFORMANCE



▲ Low Effectiveness      ▲      ▲      ▲      High Effectiveness

Figure 21. Trainer Evaluations: Task Performance Realism  
(N= 12, 3, 4, 4, 4)

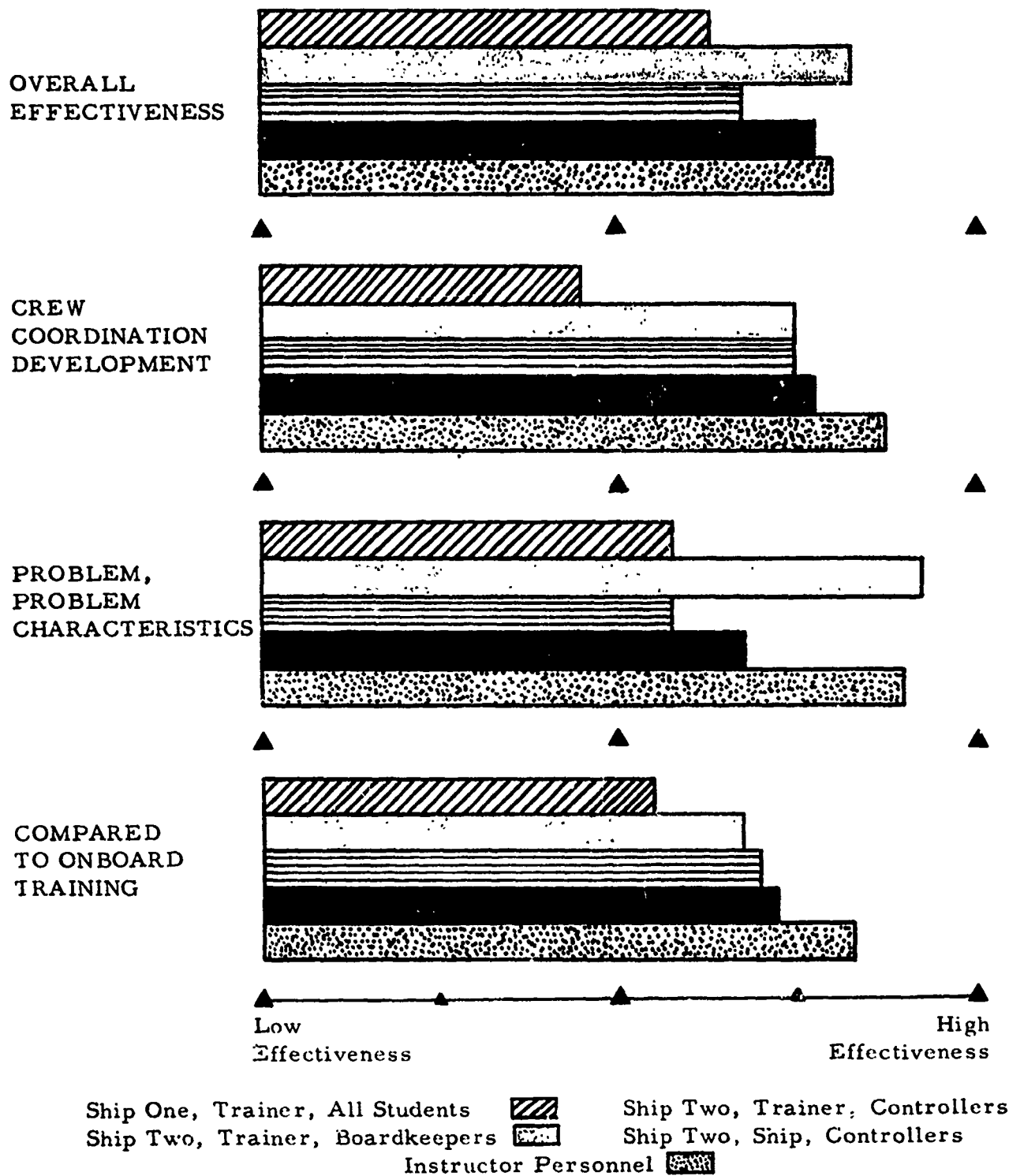


Figure 22. Trainer Evaluations: Training Effectiveness  
(N = 13, 4, 4, 4, 4)

TABLE 6

Average Responses to Questionnaire Items  
Related to Trainer Realism vs. Effectiveness Characteristics

	TRAINER REALISM		TRAINING EFFECTIVENESS
	Task Environment	Task Performance	
Student Controllers	3.2*	3.4	3.6
Instructor Personnel	4.0	3.9	4.4

\*Mean response using a five point scale where 1 = Low Effectiveness or Low Realism and 5 = High Effectiveness or High Realism.

TABLE 7

Comparison of Questionnaire Responses  
Made During Training vs. Operations

	TRAINER REALISM		TRAINING EFFECTIVENESS
	Task Environment	Task Performance	
Training	3.4	3.5	3.7
Operations	2.9	3.4	4.0

- c. When student controllers reevaluated the trainer after having controlled actual recoveries they found the device less real, but more effective. Specifically, they gave lower evaluations of environmental realism, similar evaluations of task performance realism, and higher evaluations of training effectiveness (Figures 20-22 and Table 7).

The most essential of these questions in terms of trainer effectiveness evaluation are those dealing with training effectiveness. Questions concerning environment and performance realism are important to the extent they provide information on how training effectiveness might be improved; this information is particularly important if it can be related to training weaknesses identified by the objective or evaluative data. On the whole, both objective and evaluative performance data have indicated the CATCC trainer to be quite effective. The general trends of the device evaluative rating data presented above describe the same picture. It is also true, however, that some of these data and certain observations indicate that device training effectiveness could be improved. Student comments and suggestions, made in conjunction with their ratings, are relevant to these considerations and are discussed in the following paragraphs.

**TASK ENVIRONMENT REALISM: TARGETS AND OTHER RADAR DISPLAY MARKINGS** All responses to this question criticized the radar displays on one or both of two counts: (1) Targets are too large and distinct, and (2) Target displays are too persistent (i.e., do not "fade"). It is interesting to note that CATCC crews from the Atlantic fleet coming to the training device make just the opposite criticisms; i.e., that the display quality is too poor and not persistent enough. Device radar displays simulate displays which are intermediate in distinctness and persistency between those found in the Pacific vs. the Atlantic fleets. As the device must serve both fleets, and there is no evidence that training effectiveness was degraded by this lack of complete realism, this appears to be a reasonable decision.

**TASK ENVIRONMENT REALISM: RADAR DISPLAY BEHAVIOR** Target behavior within a ten mile radius of the ship was strongly criticized. Further, it is apparent from the associated comments that some of the lower ratings given the item above reflected controller opinion regarding target behavior (rather than display realism, the question asked). The criticisms were related to target movement (spasmodic, turns too large) and to target response to control communications (time lag too long).

The lower ratings given this realism characteristic are important in that some of the associated comments indicated that it may have affected the controllers' guidance behavior in the trainer (e.g., "... due to large turns and at times extreme control required, realism fades to non-existent at times", "Targets behave realistically when the program is running good, Otherwise, forget it.") Further, it will be recalled (p. 2-4) that the controllers evaluated their guidance performance as poorer in the trainer but as quite adequate during operational recoveries; while pilots gave their lowest evaluations of controller performance in the guidance category. Based on these evidences, it is suggested that the training device is not entirely adequate in training guidance behaviors and that this inadequacy is caused by unreal target movement and response to controller communications within the ten mile radius. It is suggested that students may not be learning acceptable guidance criteria (i.e., may be accepting larger flight path and pattern deviations during operations than are necessary) and that development of optimal guidance control behaviors in training may be difficult where target response is not fairly realistic or consistent.

There are two actions that can be taken which would improve the realism of target behaviors, one of which is currently being implemented: (1) Develop software programs which will cause more realistic target movements (such programs are presently in development and expected to be in operation soon) and (2) Use only those personnel who can meet acceptable performance standards to fill pilot positions in PC & E. The latter action relates to the response time lag criticisms and to observations of controller irritation and confusion on those occasions where pilots responded incorrectly. As trainer utilization increases (and it does appear to be increasing), it will become easier to maintain a staff of trained pilot personnel, thus implementing this action to some extent. Complete implementation may require more formal pilot training and qualification procedures than are currently in effect.

**TASK ENVIRONMENT REALISM: SITUATIONAL RESPONSE TO STUDENT PERFORMANCE** Few critical comments were made to this question and none that suggested training device modification (e.g., "Bolter and wave-off rate too high"- which, incidently, is a problem variable purposely used to develop team capability to handle a high rate; "A longer time for training"). It can also be noted that the ratings on this environmental realism characteristic tended to be higher than on the previous two (Figure 20).

**TASK ENVIRONMENT REALISM: TRAINING PROBLEMS** A review of comments made on this item and on an item concerning the training effectiveness of the problems suggests that controllers with actual CATCC experience tend to feel that real problems are being simulated: "Problems equal to if not greater than problems encountered in the fleet", "Overall presentation of problems are a close parallel to actual operations", "Problems should be more complicated". In contrast, controllers without previous CATCC experience tend to feel that operational recoveries can't be that difficult and such problems don't really exist. "You wouldn't find that many problems in a recovery", "There are too many off the wall conditions thrown in that do not exist", "Things go a bit smoother (during operations)". With respect to the foregoing comment re: nonexistent conditions, an instructor response to the same question is pertinent: "We use actual situations we have been involved in." With respect to the last criticism re: smoother actual operations, a comment made by this same controller on his self-evaluation form after an operational recovery is of interest: "It will all work out (I hope!)". In summary, the training problems appear to be realistic and to serve training objectives.

**TASK PERFORMANCE REALISM: COMMUNICATION** The questionnaire did not request comments on ratings of task performance realism (Question 12). However, comments made in response to other questions provide a basis for a discussion on communications performance realism and suggest the need for such discussion. As the communications channels set up in the training device are the same as found on Ship Two, Ship Two controllers had little difficulty accepting the realism of the communications simulation (Figure 21). Trainer communications realism was downgraded after onboard experience due to serious problems with the onboard communications equipment (cf., Figure 21).

Ship One controllers did not, however, accept the trainer communications set up as a completely real one. As the training device is not presently equipped with a CATCC intercommunication system (ICS), crews from ships having this equipment (e. g., Ship One) cannot integrate its usage into the coordination procedures they develop during device training. The effect of this lack of device simulation capability is reflected in the lower ratings given to Communications Performance Realism (Figure 21) and Crew Coordination Development Training Effectiveness (Figure 22) given by the Ship One crew.

Although the actual impact of ICS vs. no ICS conditions on coordination procedures and communications performance may not be extensive

and, therefore, may not have to be considered for training purposes, it is generally felt that training device acceptance enhances training device effectiveness. Although it may be advisable to continue to train the crews from all ships to perform without use of the ICS (in preparation for degraded or failed communications equipment conditions), it is suggested that availability of ICS equipment in the CATCC training device for use by crews from ICS-equipped ships will increase controller acceptance and, as a result, may increase training effectiveness.

**TRAINING EFFECTIVENESS: CREW COORDINATION DEVELOPMENT**  
Again, comments were not requested with respect to this rating (Question 2), but responses made elsewhere in the questionnaire relate to this effectiveness characteristic and will be discussed here. (Crew coordination in terms of communications procedures is discussed in the above paragraphs.)

It will be recalled that the Approach controller performs two functions, control and integration (see p. 21 and Figure 3). There are a few CATCCs which are equipped such that the integration function can be performed by a separate controller (called a Bolter/Waveoff controller) to whatever extent the CATCC team chooses. The CATCC on Ship One is equipped in this manner but the training device is not presently configured to allow realistic training in this position with associated development of crew coordination procedures. Although the Ship One Bolter/Waveoff controllers could have practiced both their control and integration skills in the training device as it is presently configured, they did not do so. It appears that one reason they did not do so may have been their judgment that crew coordination skills relevant to their position could not be realistically developed (Lack of) internal communications between Bolter/Waveoff and Letdown controllers (is ineffective)", "The course should be able to duplicate the different CCA set-ups aboard ship. We are unable to implement our Bolter/Waveoff position"). This is of particular importance because the evidence suggests that the conflicts occurring on this ship (p. 67) might have been avoided if these personnel had taken advantage of the Approach control training provided by the trainer; and probably would have been avoided if they had either trained as a team with this position or had made a clear decision not to implement this position on-board.

It is suggested that either one of two approaches be taken to provide training to crews from ships equipped for the Bolter/Waveoff position:  
(1) That the present equipment configuration within the CATCC training

device be retained and that communications equipment necessary to implement the Bolter/Waveoff position be added. This would permit the position to be simulated to some extent, thus allowing skills and coordinations procedures to be developed. To the extent control and integration skills require more extensive practice, these personnel could be encouraged to perform in the Approach control position. (2) That the CATCC training device be equipped and reconfigured such that an actual Bolter/Waveoff position is available for those crews desiring to train with this position.

#### TRAINING EFFECTIVENESS: COMPARED TO ONBOARD TRAINING

All the comments made with regard to this question suggest the same conclusion: the "real thing" provides the best training but that on-the-job training is entirely too dangerous. (At present, the only feasible onboard training program is on-the-job training.) Further, the training device has the effective features of flexibility and instructional opportunity. A wide range of possible operational problems and conditions can be simulated, providing repeated exposure to difficult situations that require coordinated and appropriate responses. The trainer is also flexible in terms of the load conditions that can be imposed on a student. The ability to stop a recovery problem or to repeat the same problem provides opportunities to instruct and discuss problem areas, and or procedures to be developed, practiced and evaluated.

**NTDS SYMBOLOGY EFFECTIVENESS** Question 9 asked, "How effective is the symbology in aiding the controller at your position?" The average rating was 1.4 (1.0 = Low Effectiveness) and all comments lead to the same conclusion: Without automatic tracking of the aircraft by the symbols, the symbology is a hindrance and possibly a danger; with automatic tracking, it is feasible but the controllers question whether the possible value of an additional information source is worth the scope clutter and interference with the "real" video world caused by the symbology. The question of the value of NTDS symbology to CATCC operations may be worth investigating in more detail.

#### ADDITIONAL EFFECTIVE AND INEFFECTIVE TRAINING DEVICE

**CHARACTERISTICS** The majority of comments made in response to questionnaire items have been covered by the above discussions. One additional type of comment was made, however, which does not relate to training device effectiveness characteristics but rather to training device utilization. This type of comment was made by Ship One controllers during their first week of training: "Occasionally allow a problem to run smoothly with little or no changes so as to build some confidence in



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controllers. With every problem a 'flail' one begins to develop doubts in one's ability." This comment was made in spite of the fact that the recovery problems performed by this crew were generally much easier than those performed by the Ship Two crews.

Unfortunately, there are presently no regulations in effect which require a CATCC crew to remain in training until a determination of "qualified" is made by instructor personnel. As a result, instructors must make maximum use of the known available time to prepare the crew for the situations that can arise in the operational environment. The instructional problem is compounded by the empirical facts that changes in team and subteam composition tend to present new team and subteam learning requirements. These compositional changes occur throughout training. Further, new requirements for individual training continue to arise throughout training whenever cross-training takes place. As a result of these time constraints and learning requirement multiplications, instructors must compromise the development of confidence and full proficiency to ensure the development of crew coordination procedures and implementation methods adequate for the operational situations that can and do arise. It is suggested that CATCC qualification procedures and standards be developed and that qualification requirements be established, so that the full potential of the training device can be realized. The impact of CATCC on safe and efficient carrier recovery operations is sufficient to render these suggestions worth consideration.

## APPENDIX C

## OBJECTIVE PERFORMANCE MEASURES: DEFINITIONS

The system criteria each measure relates to and the control position or positions measured are described in the text (Tables 3 and 4). Further, each measure is generally defined in conjunction with the presentation and discussion of data (Study Results, Section III). Some of the measures, however, warrant a more detailed definition, or formulation; these are presented below.

## AVERAGE AIRCRAFT SEPARATION ERROR

A deviation of  $\pm .5$  minutes from the scheduled separation time of 1.0 or 2.0 minutes between aircraft crossing the ramp is considered acceptable. Unless there are extenuating circumstances (e.g., degraded radar), any deviation larger than  $\pm .5$  minutes is considered to reflect poor control. The measure of average team error on any single recovery,  $y$ , was computed as follows:

$$y = \frac{\sum_{i=2}^m |t_i - 1.5| + \sum_{i=2}^n |t_i - .5|}{c}$$

where  $t_i$  = time interval between aircraft<sub>*i*</sub> and aircraft<sub>*i-1*</sub>, measured as they cross the ramp;  
 $m$  = number of separation time intervals greater than 1.5 minutes;  
 $n$  = number of separation time intervals less than 0.5 minutes;  
 and  $c$  = total number of ramp crossings.

## COMMUNICATIONS EFFICIENCY AND NOISE LEVEL

Both communications measures were ratings made at the conclusion of each recovery using a five point continuous scale:

Very Inefficient	Very Efficient
Very High Noise Level	Very Low Noise Level

## RADAR CONTACT NOT ANNOUNCED TO PILOT

Both Approach and Final controllers are required to announce radar contact to the pilot whenever a new contact is made. Four measures of this aspect of procedural performance were obtained on each recovery, one for each Approach controller ( $y_1, y_2$ ) and one for each Final controller ( $y_3, y_4$ ):

$$y_i = \frac{N_{na}}{N_m} \times 100$$

where  $N_{na}$  = Number of contacts not announced by controller  $i$ ,

and  $N_m$  = Number of contacts made by controller  $i$ .

## NUMBER OF CONFLICTIONS

Jet aircraft within the recovery area (spec. , within a 50 mile radius of the ship) but not on the approach path are considered to be in a confliction situation if they are not separated laterally by at least 3 miles or vertically by 1000 feet (a greater vertical separation is required above 29,000 feet but this was not pertinent to observed recoveries). The determination of which controller(s) were at fault was based on observation of the developing situation and on later detailed analyses of the descriptive data for that recovery (e. g. , tracing the evolution of traffic pattern changes and relating them to individual controller actions).

APPENDIX D

EVALUATION FORMS

CATCC TRAINER EVALUATION

Name \_\_\_\_\_ Date \_\_\_\_\_

Primary Control Position \_\_\_\_\_

INSTRUCTIONS

As part of an evaluation of training device effectiveness being conducted for the U. S. Navy we would like you to answer the following questions as completely and honestly as you can. This is not a test: there are no right or wrong answers. Rather, your carefully considered responses describing the role the trainer has played in preparing you for your position are sought.

Some of the questions require two kinds of answers: a rating of the device or its characteristics and your own explanation of that answer. Please be as detailed as you can.

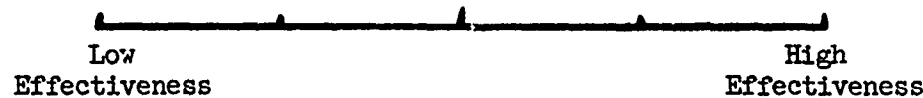
1. Overall, how effective would you say the Carrier Air Traffic Control Center training device is as a trainer for this position?



2. How effective is the trainer in developing the crew coordination skills required as a member of an operational crew?



3. How effective are the problems and problem characteristics in providing training for this position?



Would you change the problems presented to you, and, if so, in what way?

4. How effective do you think the trainer is compared to an equivalent amount of onboard (carrier) training?

Low Effectiveness High Effectiveness

Explain here if you wish.

5. How realistic are the targets and other radar produced markings in the trainer?

Low Realism High Realism

Comments?

6. Does the displayed information behave realistically and appropriately? What and where would you suggest improvements?

Low Realism High Realism

7. How realistic is the response of the training situation to your performance as compared to what would happen in the carrier situation?



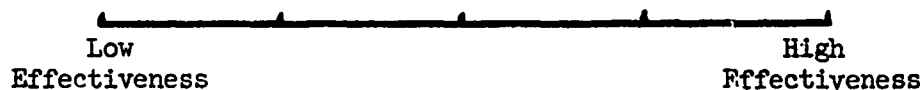
What changes would you suggest, if any?

8. How realistic are the training problems as compared to the real situation?



Comments?

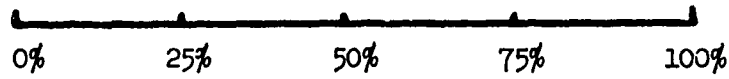
9. How effective is the symbology in aiding the controller at your position?



Why?



10. What percentage of the time did you use the symbology?





11. What characteristics of the device would you say contribute to its effectiveness or ineffectiveness (but have not discussed above)?


Effective Characteristics	Ineffective Characteristics

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12. Compare and rate the realism of the trainer to the carrier situation for the following five major items:

Communication   
 Low Realism High Realism

Guidance Control   
 Low Realism High Realism

Contingency Handling   
 Low Realism High Realism

Emergency Situation   
 Low Realism High Realism

Your Performance   
 Low Realism High Realism

13. Any additional comments, suggestions or statements?

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CONTROLLER EVALUATION FORM

Instruction. Using the three point rating scale presented on the following page, please evaluate and rate your performance in the five major areas of communication, guidance, emergency procedures, contingency handling, and overall performance. Before responding, please consider and assess your performance relative to accuracy of information, adequacy of information, timeliness of information, coordination of situation, safety adherence and continuance, requirement for information, and other pertinent standards you feel should be considered in the evaluation of your performance as a controller.

Comment. The information gathered in this evaluation package will be held in the strictest confidence (the study evaluators will be the only personnel to see the evaluation packages). Your name and responses will not be used individually, but as a collected whole in achieving an evaluation of controller performance in the Carrier Air Traffic Control situation.

If there are any questions, please ask them.

Thank you for your full cooperation.

## CONTROLLER EVALUATION FORM

CONTROLLER POSITION: \_\_\_\_\_ TIME: \_\_\_\_\_

		Poor	Good	Exc	ANY PROBLEMS
COMMUNICATIONS	All previous exp. Prev. current cruise				
GUIDANCE	All previous exp. Prev. current cruise				
EMERGENCY PROCEDURES (if occur)	All previous exp. Prev. current cruise				
CONTINGENCY HANDLING	All previous exp. Prev. current cruise				
OVERALL PERFORMANCE	All previous exp. Prev. current cruise				

A horizontal scale with five vertical tick marks. Below the first tick mark is the word "Poor". Below the third tick mark is the word "Average". Below the fifth tick mark is the word "Excellent".

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CONTROLLER EVALUATION

1. What problems did you experience during the exercise?
2. Did the NTDS Symbology pose any problems? Explain.
3. Did you have any coordination and/or handling problems with other CCA personnel? Explain.
4. Did you maintain adequate separation of aircraft? Explain.
5. Any suggestions or comments?

ISO EVALUATION OF EXERCISE

Instructions. Please enter the evaluation information requested on the following page based on your total ISO experience. In responding, please consider and assess the situation presently being evaluated versus a situation you as ISO would consider as a standard on which to make a comparison judgment. Realizing that each approach to landing is unique in itself, it is hoped that you as ISO can through your experience rate the performance of the approach to the overall approach situation being experienced on that specific approach.

Comment. The information gathered in this evaluation package will be held in the strictest confidence (the study evaluators will be the only personnel to see the evaluation packages). Your name and responses will not be used individually, but as a collected whole in achieving an evaluation of controller performance in the Carrier Air Traffic Control situation.

If there are any question, please ask them.

Thank you for your full cooperation.

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2)

[illegible]

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## LSO Evaluation

1. Do you feel there is any performance difference between Final Controller A or Final Controller B? Explain.
2. Were the missed app due to pilot technique or controller technique (Please specify A/C)?
3. Any suggestions or comments?



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PILOT'S EVALUATION OF EXERCISE

Instructions. Using the three point rating scale presented on the following page, please rate each specific controller's performance for the five major evaluation areas of communication, guidance, emergency procedures, contingency handling, and overall performance. Before responding, please consider and assess the controller's performance relative to accuracy of information, adequacy of information, timeliness of information, coordination of situation, safety adherence and continuous, requirement for information, and other pertinent standards you feel should be considered in the evaluation of controller performance.

Comment. The information gathered in this evaluation package will be held in the strictest confidence. The study evaluators will be the only personnel to see the evaluation packages. Your name and responses will not be used individually, but as a collected whole in achieving an evaluation of controller performance in the Carrier Air Traffic Control situation.

If there are any question, please ask them.

Thank you for your full cooperation.

## PILOT EVALUATION RATING FORM

Pilot: \_\_\_\_\_ A/C#: \_\_\_\_\_ Assign. DIS-ANG: \_\_\_\_\_ EAT: \_\_\_\_\_ Btn.: \_\_\_\_\_

TIME: \_\_\_\_\_

DATE: \_\_\_\_\_

Controller/Phase of Approach	Marshall			Approach			Final			ISO		
	Poor	Good	Exc	Poor	Good	Exc	Poor	Good	Exc	Poor	Good	Exc
COMMUNICATION All prev. exp. Prev. current cruise												
GUIDANCE All prev. exp. Prev. current cruise												
PROCEDURES (if occurs)												
CONTINGENCY HANDLING All prev. exp. Prev. current cruise												
OVERALL PERFORMANCE All prev. exp. Prev. current cruise												

NOTE THE OVERALL CARRIER AIR TRAFFIC CONTROL CENTER TEAM PERFORMANCE

Poor

Average

Excellent

COMMENTS:

PILOT EVALUATION

1. Were there any deficiencies in the five major performance areas mentioned in the rating matrix? Explain.

2. Any comments or suggestions?

## GLOSSARY

Bingo	An order to an aircraft to proceed immediately to a divert field.
Bolter	Aircraft touches down but fails to trap.
Confliction	See Appendix 3 for definition.
Delta	A six minute holding pattern at altitude and position indicated.
EAT	Expected Approach Time. The future time at which an aircraft is cleared to penetrate from a preassigned fix. Aircraft commence approach at EAT if no further instructions received.
G/A	Go Around. Aircraft completes approach but does not touchdown, entering the bolter/waveoff pattern instead.
LSO	Landing Signal Officer. Provides aircraft control instructions from visual acquisition (normally 3/4 to 1 mile out) to touchdown.
Mode III Recovery	Approaches are manually flown in response to CATCC instructions.
ORI	Operational Readiness Inspection.
PC&E	Program Control and Evaluation. The control center for the CATCC mockup.
Ramp Time	Time at which the carrier ramp is scheduled to be open for recovery operations.
Random Recovery	Aircraft are directed to carrier for recovery when possible upon arrival, rather than assembling in Marshalling area and commencing approach at EAT.

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Scheduled  
Recovery

Aircraft assemble in Marshalling area at scheduled time  
and depart on scheduled EATs unless otherwise directed.

W/O

Waveoff. An instruction to continue flight, entering bolter /  
waveoff pattern.